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ABSTRACT

A complete profile of the average (male) soccer player is established through the study of ten topflight soccer teams in the United States and abroad. Statistical averages for team age, strength and muscular power, body size and composition, agility and flexibility, lung capacity, and various other physical and physiological characteristics are given. Sociological and psychological profiles of soccer players in general are examined. The demands of competition in differing field positions are discussed, and suggestions are given for training routines to develop overall endurance as well as motor skill. References are included. (LH)

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FOREWORD

This is the eighth in a series of booklets entitled *What Research Tells the Coach About* a particular sport. It is a project sponsored by the National Association for Sport and Physical Education of the American Alliance for Health, Physical Education, Recreation and Dance. The main purpose of these pamphlets is to make available in one volume pertinent research findings recommending practical applications to only one sport. Authors selected for these series have a sound research background, and most have considerable practical experience in playing, coaching, and teaching a sport. It is believed that these qualifications make them particularly able to select research studies and point out pertinent comments that have significance for both coaches and competitors.

The author of this booklet, Professor Thomas Reilly, is a member of the Physical Education Staff at Liverpool Polytechnic in London, England. He has had coaching, teaching, and research experience in the sport of soccer. He was a soccer competitor for many years. We are fortunate to have secured his services as the author of this booklet.

Professor Reilly has done an outstanding job in reporting what the coach should know, what the researcher has discovered, and what is believed correct by the coaches and competitors in regard to soccer. He is an extremely knowledgeable man in regard to this sport. He has used some technical language, but the modern soccer coach should be knowledgeable about up-to-date research terminology, tools, and techniques. Such a coach should have no difficulty in understanding Professor Reilly's comments and reports. I believe this is an outstanding contribution to the sport of soccer.

PREFACE

*Soccer is not just a matter of life and death.
It's much more serious than that.*

— Bill Shankley

The everyday significance of soccer has at times been elevated to religious status. Since Britain exported its major team game during the second half of the last century, soccer has been selectively adopted by various cultures and with differing degrees of fervor. Shortly after the Jules Rimet trophy was instituted, it was apparent that South American countries had established an early stranglehold on the world competitive game. This has been periodically loosened by those individual European countries who successfully produced well organized and disciplined team configurations to overcome their more free-wheeling adversaries, particularly from Brazil.

Only comparatively recently have African and Asian nations become addicted to this opium of the people. The utilization of immigrant coaches, particularly European and South American, in Third World countries has not been on a scale large enough to produce results comparable, for example, to the successes of East African middle and long distance runners. In the United States little progress was apparent in public acceptability of the game for a quarter of a century after the country's defeat of England in the 1950 World Cup match at Belo Horizonte. The great push forward was begun with the heavily backed promotion of the North American Soccer League (NASL), star-studded line-ups like the New York Cosmos being to the fore. Similarly in the Middle-East and Arabian states, oil riches gave impetus to the importation of foreign coaching manpower and advice, all-weather playing surfaces and a devotion to training hitherto unknown in those

areas. Meanwhile in Europe a trend emerged in the popularization of the game as a community sport and its use as physical activity for positive health in the otherwise sedentary over-40 age group.

Here then is a game played with gusto from adolescence to incipient middle age. A multitude of self-professed experts abound — the player who professes knowledge gained by playing, the coach insisting he knows the game by knowing his players, the manager who claims knowledge through his experience, the sports journalist's knowledge acquired via sustained critical observation, the partisan fan's felt knowledge often regrettably expressed in sociably undesirable fashion on the terraces. When the research scientist steps into this microcosm, he is likely to be greeted at worst with suspicion and hostility or at best with muted skepticism. Coupled with this is the multifaceted and enigmatic nature of soccer, where match play frequently defies successful forecasting and confidently predicted outcomes are reversed and where unexpected defeats are rapidly dismissed by players and managers as accidents tantamount to acts of God. In short, myth still very much pervades the soccer world, particularly in the professional league game where outsiders purporting to represent an objective and detached perspective are either shunned or frostily welcomed. The atmosphere is generally not one conducive to attracting the research scientist with his bias towards controlled conditions and an experimental approach. These factors help to explain why this sport has received less attention from sports scientists than might be adjudged merited.

This monograph attempts to collate research publications which have implications for the soccer player and coach. Such papers range from studies on World Cup and Olympic teams to adolescent European and Asian players and embrace physical, physiological, psychological, and statistical aspects. No attempt is made to usurp the prerogatives of the practitioners in the sport, though applications of research findings to coaching and training are adumbrated where appropriate.

The author recognized the yawning chasm in soccer research a few years ago and tried to contribute to the gargantuan task of bridging it. For igniting this spark of interest and for keeping the resulting flame alight much credit is due to Vaughan Thomas, Director of Physical Education at Liverpool Polytechnic. Thanks are due to the many experimental subjects quoted in this booklet who remain unnamed. Though some progress has been made towards an objective appraisal of the game's demands and of the nature of its players, this knowledge is gained against a background of a receding horizon — each investigation prompts further questions and requests additional studies. A host of intriguing research possibilities still invite the intrepid research worker, many of these being suggested in the course of this manuscript.

1. PHYSICAL AND PHYSIOLOGICAL CHARACTERISTICS OF THE SOCCER PLAYER

A wealth of research effort has been spent in describing the characteristics of competitors in various sports (e.g. 26, 40, 48, 52, 53). These investigations have tended to concentrate on topflight performers in order to identify critical requirements for success and have described such characteristics in physical, physiological, and psychological terms. This operation increases in complexity when team games rather than individual sports are considered. Greater variability between individuals may be expected and may perhaps be necessary; this will particularly apply in a field-invasive game like soccer. This section reviews studies in physical and physiological characteristics of soccer teams to determine first how they differ from nonathletes and whether they merit description as a homogeneous group and second to discuss implications of research findings.

PHYSICAL CHARACTERISTICS

Age

The ages of some topflight teams reported by various investigators are included in Table 1. The younger professionals who had not established themselves as first team players were not included among the Tottenham Hotspur subjects. The 14 players who constituted the first team squad of Leeds United had a mean age of 27.0 years. Only two members of the squad were more than 28 years of age. It

included 12 international players who had an average of 320 first team games and represented an exceptionally experienced side.

These data suggest that the majority of top class players are in their twenties, and though a number of individuals continue to play competitively into their thirties, these tend to be the exceptions. From his study of entrants at the Tokyo Olympic Games in 1964, Hirata (29) concluded that success in ball games such as soccer, basketball, volleyball, and hockey is accomplished in the period 24-27 years of age, soccer being the earliest of these. Whether fitness, motivation, or chronic degenerative trauma explain why most players have the peak of their career behind them by the time they turn 30 is not clear. Neither is it yet established whether expected career duration differs between playing positions.

TABLE 1. BASIC PHYSICAL CHARACTERISTICS OF SOCCER PLAYERS REPORTED BY VARIOUS INVESTIGATORS. OBSERVATIONS INDICATE MEAN $\pm$ S.E. OR MEAN ONLY

	Number (N)	Age (years)	Height (cm)	Weight (kg)	Percent Body Fat
Tottenham Hotspur (23)	18	26.4 $\pm$ 0.78	178.5 $\pm$ 1.25	77.5 $\pm$ 1.34	—
English League First Division Team (43)	31	22.5 $\pm$ 0.58	176 $\pm$ 1.09	73.2 $\pm$ 1.5	—
Leeds United (1)	51	21.6	175.5	—	—
Czech Top Players (17)	18	23.5	178.4	74.9	—
Roumanian League Team (7)	16	22.5	—	—	—
Dallas Tornado (41)	18	25.6 $\pm$ 1.9	176.3 $\pm$ 1.2	75.7 $\pm$ 1.9	9.59 $\pm$ 0.73
Aberdeen F.C. (42, 58)	9	Range 19-27	171.6 $\pm$ 0.9	69.4 $\pm$ 2.1	12.4 $\pm$ 0.73
Australian National Team 1974 (18)	12	23.6	178.6	75.8	10.8
Japan National Team 1964 (30)	19	—	171.2	66.4	—
Southern Australian Representatives 1977 (61)	5	24.4 $\pm$ 2	178.1 $\pm$ 3.6	75.2 $\pm$ 2.2	15.7 $\pm$ —

Body Size and Composition

Data on the height, weight, and percentage body fat of soccer players are included in Table 1. The Aberdeen F.C. players were compared to University Rugby players and were found to be significantly smaller (58). English college players had mean values of 176.3 cm, 71.26 kg, and 14.94% for height, body weight, and percentage body fat respectively (9). They had less body mass but higher fat percentages than the Dallas Tornado professionals who were of identical mean height. A Zagreb investigator classified players according to level of performance and concluded that players of top class ability were slightly smaller and had less weight than those of moderate ability (38). Active adult amateur players in the city ($N = 2,866$) tended to be smaller than an inactive control group.

Hirata's study of Tokyo Olympic Games players led him to conclude that the physique of soccer players was "rather small and a little stout." Japan's 1964 Olympic Games team were especially small and light for playing at this level and illustrate characteristic ethnic differences, Asians on the whole being small in development (29).

These figures indicate that soccer players may come in a variety of body sizes. None of the groups in the reports cited had as little body fat as the 8.3% reported for attacking and defensive American football backs (60) or the value of 7.5% found in marathon runners (20). Values as low as 2.4% were reported for cross-country and marathon runners. The mean percentage body fat obtained from Brazilian soccer players by De Rose (25) was 10.65%, the national level players being just below 10%. American college soccer players averaged 9.3% (20). Since fat constitutes dead weight in activities requiring the repetitive lifting of body mass, the data from the soccer players studied probably represents superfluous fat to a lesser or greater degree, even though they are considerably less than the 16.5% average for normally active Americans of comparable age.

Somatotyping provides a convenient method of describing the morphology of sportsmen. Intense long-term activity in a certain event can result in a similar somatotype of involved individuals. In addition, in many sports capability for top performance may be limited to those competitors with the necessary somatic predispositions. The combination of adaptation and endowment helps to explain the persistent finding that top performers in certain sports differ in body constitution from the average population.

The somatotype of English college players seemed to vary around a basic 3:5:2.5 (9). The mean value for top Czech players was 2.5:4.6:2.5. This group merited the description of middle to strong mesomorphs (17). The mean rating of the Australian soccer squad was 3:5:3, indicating again a tendency towards mesomorphy. This could be expected to benefit the soccer players in many of the variegated contexts of the game, for instance in tackling, turning, accelerating, and kicking, conditions where increased muscularity should be advantageous.

An endomorphy rating of $2.8 (\pm \text{S.E.} = 0.14)$ was reported for English League players (43). These subjects' estimated body surface area was $1.87 (\pm \text{S.E.} = 0.018 \text{ m}^2)$. When they were compared with the 1960 Olympic athletes studied by Tanner (52) where measurement procedures were similar, the English League players closely resembled the 400 m hurdlers in weight and thigh circumference, but were smaller, with higher skinfold thicknesses and higher endomorphy ratings. Thigh and calf circumferences, endomorphy, and skinfold thicknesses were close to the values obtained for triple jumpers, who were lighter and taller. The soccer players were unlike any of the other Olympic track and field athletes. Controlled explosive effort is required in the triple jump and to some extent in the 400 m hurdles, a requirement also in many competitive footballing contexts. The English League players were heavier and smaller than the Olympic athletes they most closely resembled in physique.

Comparison of mean scores may have only limited value when individual variance is large. A particular stature or physique may be best suited to a specific playing position or tactical role. The sample of Australian subjects was small in number and consequently only tentative conclusions were drawn (18). Generally it was seen that the defenders tended to be the taller and heavier members of the squad, whereas the mean height and weight of the midfield players were well below the overall squad means. The greatest heterogeneity was found among the attackers.

The study of English college players (9) showed that goalkeepers were taller ($\bar{X} = 180 \text{ cm}$) and had more body fat (16.5%) than outfield players. The shortest outfield players were the midfielders ($\bar{X} = 173 \text{ cm}$). The outfield players differed little between groups in body fat where the range was only from 14.64 to 14.74%. No difference in somatotype was apparent between defenders, midfielders, and strikers (attackers). Goalkeepers ($\bar{X} = 81 \text{ kg}$) were heaviest with midfielders ($\bar{X} = 68 \text{ kg}$) lightest. The goalkeepers had higher values for arm length than any outfield group, which would constitute an advantage for playing in this position. However, when arm length was expressed as proportionate to stature to remove the effect of body size, this difference was not significant. Similarly, no significant differences in somatotype were detected between the playing positions. The authors concluded that at this somewhat low level of ability the players represented a morphologically homogeneous group.

Raven and coworkers (41) also found that, among 18 NASL players, goalkeepers were taller, heavier, and had more body fat than outfield players. Comparison of various outfield groups was not warranted by sample size in the study.

Reilly (43) reported that among defenders center backs were taller than fullbacks; fullbacks and goalkeepers were the tallest members of the professional playing staff, the smallest being the midfielders. A principal component analysis of fitness data on soccer players obtained by means of a multi-itemed test battery

showed that 23% of the total variance between individuals could be accounted for by a component related to body size, while a further 10% was explained by a component related to body density (45). A cluster analysis of these results showed that center backs congregated, as did goalkeepers and midfielders, while attackers with similar tactical roles also grouped together. The attackers who functioned as target men and operated mainly in a central position (being reputedly good in aerial tussles for possession) closely resembled the center backs, while the fullbacks were the more heterogeneous group. This analysis indicated that players who did not gain First Team selection clustered together, suggesting that physical characteristics may have contributed to their failure. The investigation concluded that clustering according to positional role wasn't absolutely clear-cut, due to the presence in the squad of a number of individuals, particularly the younger players, who had the capability to change positional roles as tactics and emergencies dictated. Inclusion of such versatile individuals in the team may be desirable for tactical purposes.

The establishment of definite distinctions between playing positions on the basis of anthropometric data demands larger samples than have hitherto been studied at top level and subjects well established in clearly defined roles. It is also likely that anthropometric indices will vary with ethnic groups though the exact nature of differences in soccer does not seem to have been investigated. It is also possible that a coach may modify his team configuration and style of play in order to accommodate individuals who do not possess expected physical attributes of the conventional positional roles but who compensate by superior skill and motivation levels.

Strength and Muscular Power

Grip strength has been used for the last half century as an indicator of gross body strength (47). The grip strength of 31 English League professionals was 50.4 ($\pm$ S.E. = 1.17) kg (43). This was similar to results for scuba divers (55), lawn tennis players (53), fencers, gymnasts, and swimmers (54), and slightly higher than the 46.2 ($\pm$ S.E. = 0.3) kg found in the Dallas Tornado players. The mean grip strength of Japanese internationals was 52.9 kg (31). These scores approximate expected figures for normal individuals of similar age and body size. From the tendency towards mesomorphy apparent in soccer players, stronger grips might be expected. The back strength of the Japanese internationals was 148.8 kg which was equivalent to values obtained for 20-year-olds in the general population. Raven and coworkers (41) used one repetition maximum bench press (24) as a field test of fitness of their professional soccer subjects and obtained a mean value of 73 ($\pm$ S.E. = 4.1) kg.

Isometric strength data measured using cable tensiometry have been reported for a range of muscle groups in the English professionals (43). No significant contralateral limb differences were observed. This is an important safety factor as a strength imbalance between limbs increases the likelihood of injury. Though the wisdom of comparing isometric strength data from laboratories in different countries is questionable because of the necessity of duplicating test procedures for valid comparisons to be made, tensiometry testing can assist in identifying those individuals susceptible to injury because of strength limitations. Functional discriminatory analysis of isometric strength and muscular power data successfully separated the First Team and Reserve Team squads in an English League club, the superior values being found in the upper level of playing proficiency (45).

Strength in the lower limbs is of obvious concern in soccer. The quadriceps, gastrocnemius, and hamstrings must develop the explosive force used in jumping, kicking, and turning. The capability to sustain a contraction is also required for balance and ball control. Shephard (50) suggested that isometric strength is important in maintaining a players' balance on a slippery field, and also contributes to ball control. For the goalkeeper almost all of the body's muscle groups are important. For outfield players the lower part of the trunk, the hip flexors, and the plantar and dorsi flexors of the ankle are used most frequently.

The data reviewed indicate that soccer players are not above average in static muscular strength. An explanation for this may lie in inadequate attention paid to resistance training in their habitual training regime (43). Isometric strength may not truly reflect the ability to exert force in dynamic conditions. Brooke and coworkers found nonsignificant correlations between soccer kick length and static and explosive leg strength (12). A leg dynamometer was used to measure static strength while a short shuttle run and a modified vertical jump was used as the index of explosive leg strength. The investigators tentatively concluded that a degree of learned skill in the applied task of kicking predominated over the degree of basic strength required.

Explosive leg strength is indicated by vertical or standing broad jump. The vertical jump performances of the Dallas Tornado players was 52.8 ($\pm$ S.E. = 2.5) cm, and of the Australian World Cup Squad 49.9 cm. English League players cleared 219 ($\pm$ S.E. = 2.97) cm in a standing broad jump test and 58.0 ($\pm$ S.E. = 1.12) cm in a vertical jump. The superior performances were found among the goalkeepers and center backs and in strikers who operated as "target men" for defenders to hit long high passes to. Midfielders had relatively low scores in both tests (46). Performances of two center backs and one striker in the vertical jump test were similar to results reported for 7-foot high jumpers (32).

Cochrane and Pyke (18) reported the highest values in strikers among their Australian subjects for vertical jump, these players also having the fastest times in a 40-yard (36.58 m) dash test. The attackers were rated above average on the standards prepared for Australian football. The midfielders were the slowest

group. It seems that exceptional explosive leg power is required in center backs, goalkeepers, and in specific striker roles, but that this is not a critical requirement for playing in midfield.

Soccer players are frequently called on to sprint over short distances. The maximal power that an individual can develop in exercise of short duration is based on the splitting of high energy intramuscular phosphagens (16). These sources are limited but are most readily available for combustion by muscle at the onset of exercise and result in anaerobic work without lactate production. The maximum alactic anaerobic power ($\dot{W}_p$ max) can be expressed as maximal power output (kgm/kg/minute) by the method of Margaria and colleagues (36), which requires the subject to sprint up a stairway of prescribed dimensions. The anaerobic power of Olympic Games soccer players measured in this way and expressed in energy consumption was 5.8 h.p. (26). This compares with observations on pentathletes of 6.8 h.p., sprinters 6.2 h.p. and middle-distance runners 6.3 h.p. Besides these groups long-distance runners and wrestlers had greater anaerobic power per kg body weight than the soccer players. Other investigations however found higher values in representative soccer players ($\bar{X} = 1.65$ kgm/kg/seconds) than in basketballers, walkers, and runners at the same competitive level (61). Caru et al. (15) measured $\dot{W}_p$ max in 95 young footballers aged 14-18 and found values significantly higher than in nonathletic subjects of similar ages. No significant difference was apparent between any of the playing positions examined. Mean values for the different age groups ranged from 1.527 kgm/kg/seconds at 14 to 1.647 kgm/kg/seconds at 18.

The main parameter describing the anaerobic capacity of the whole body is related to muscle fiber composition, specifically the percentage of fast twitch (FT) fibers in the quadriceps (33). The importance of percentage fiber compositions or relative area occupied by FT fibers has not been seriously studied in soccer players.

Agility and Flexibility

Because of the continued requirements in soccer play to accelerate, decelerate, turn, and side-step, agility is a critical requirement. Agility is defined as "the ability to change direction of the body and its parts rapidly" and can be measured by standardized run tests. The Dallas Tornado players had a mean time of 15.56 ($\pm$ S.E. = 0.14) seconds for the Illinois Agility Run. All playing groups scored above the 99.95 percentile and the mean of the players was above the 99.9 percentile of the standard scores established by Cureton (22). This test distinguished soccer players as a group from the normal population better than any field test used for strength, power, and flexibility. The investigators concluded that the agility of players was their greatest asset and set them apart from normal individuals.

Players must frequently execute skills of the game while balancing on one leg. The "stork stand" used by the Canadian Soccer Association provides a convenient field test of this skill (50). One foot is rested on the inside of the opposite knee, the player standing as long as he can with his hands on his hips and his eyes closed. A laboratory stabilometer gives a general measure of balance. Here the subject stands astride a teeter-totter and tries to stop it oscillating; either the angle of swing in a given period or the time before one end of the teeter-totter hits the ground is recorded. It is not clear to what extent these balance tests discriminate between levels of playing proficiency.

Many playing positions call for an extreme range of joint movement. It seems that mobility or flexibility is specific to a joint. The sit and reach test of Kraus-Weber (34) gives an indication of static flexibility in the trunk. Mean performance on this test by the NASL players was 51.3 ($\pm$ S.E. = 1.78) cm with individual values ranging from average to excellent when compared with the normal population. The goalkeeper performed better than all other groups. Mobility at the angle joint of English League players was 62 ($\pm$ S.E. = 1.5). This agrees with normal figures for this joint for adult male subjects (39). Values were, however, significantly less than observed for male subjects aged 14-18 years. It seems that soccer players, with the exception of the goalkeeper, may not be superior to the normal population in mobility, and that this function particularly in the ankle joint may deteriorate with age. The results probably reflect the inadequate attention given to mobility exercises in the training regimes of soccer players (1, 43).

Lung Function

Pulmonary function tests are frequently used as a measure of the adequacy of the respiratory system. Vital Capacity (VC), the volume of gas that can be forcibly expired after a maximum inspiration, represents the approximate usable capacity of the lungs. The Residual Volume represents the air remaining in the lungs after a complete exhalation and cannot be exhaled. The measures of lung function in the Dallas Tornado players (41) showed mean values of 5.29 ($\pm$ S.E. = 0.174) l for VC (BTPS), 1.385 ($\pm$ S.E. = 0.117) l for Residual Volume, and 6.735 ($\pm$ S.E. = 0.224) l for the Total Lung Capacity. Mean VC for the English League players was 5.8 ($\pm$ S.E. = 0.18) l at the start of pre-season training and 5.9 ($\pm$ S.E. = 0.16) l at the beginning of the competitive season (46). These values are significantly higher than the 5.15 ($\pm$ S.E. = 0.06) l predicted from height and age using a standard nomogram (28). Several authors have reported that VC is higher in athletes than in nonathletic subjects of similar body size (35, 51), though the relative contributions of heredity and training to this superiority haven't been clearly established.

The lung power of the English League subjects as indicated by mean FEV_1 (forced expiratory volume in 1 second) was $4.95 (\pm S.E. = 0.16) l$, significantly higher than the predicted value of $4.3 (\pm S.E. = 0.04) l$. Forced Expiratory Flow was $10.6 (\pm S.E. = 0.32) l/\text{second}$ (43).

It seems that VC represents a structural component of the body, similar to other anthropometric assessments of body size; this is the basis for predicting pulmonary capacity from body surface area or size measures. It seems also that VC can be significantly enlarged as a result of long-term training over a number of years (11). Several studies, however, have shown no improvement in lung function measured in single maximal breaths (2, 46, 56), though significant changes in swimmers over a 4-month period have been found (6). Shaver (49) concluded that a season of varsity wrestling competition can induce significant changes in VC, inspiratory reserve volume, and Maximum Breathing Capacity.

Lung function measures have been found to correlate well with a variety of strength tests in young boys (57), probably because of the effect of body size. Isiniko examined the relationship between lung function and endurance performance (30). There was no significant correlation between 5000 m run time in international track runners and VC expressed in absolute terms and relative to body mass. The maximal oxygen uptake ($\dot{V}O_2 \text{ max}$) — the capacity of the tissues to consume oxygen during severe exercise — was not significantly correlated with VC when both variables were corrected for body weight. The $\dot{V}O_2 \text{ max}$ depends on pulmonary ventilation, pulmonary diffusion, the oxygen-carrying capacity of the blood, cardiac output, and arteriovenous differences in oxygen saturation. These results cast doubt on the importance of single breath spirometry tests, though they have obvious value in screening for pulmonary deficiencies and obstructions. It is however reasonable to expect that the Maximum Breathing Capacity (MBC), the maximum volume of air that can be breathed per minute, must be high in order to furnish the oxygen transport system with necessary supplies for 90 minutes of soccer play. This probably requires superior respiratory musculature rather than excessively large lungs. The pulmonary function does not normally appear to be a factor limiting the maximum aerobic performance.

PHYSIOLOGICAL CHARACTERISTICS

Circulatory Measures

The heart responds to training by becoming larger and more effective as a pump. The chambers increase in volume and the walls of the heart thicken and grow stronger. Cardiac muscle hypertrophy is reflected in a greater stroke volume which

in turn is manifested in a slower rate of beating at rest. This reduction in resting heart rate is particularly apparent in well-trained endurance athletes. The figures in Table 2 suggest a large degree of cardiac entraining with mean values of 50 and 48 beats/minute for North American and English League players. Values of similar magnitude (mean $51.8 \pm \text{S.E.} = 1.6$) were reported for the Roumanian League Champions resting in the supine position. These values are marginally lower than the 54 beats/minute reported by Thomas (54) for several hundred international standard sportsmen. Resting cardiac efficiency was identified by Reilly and Thomas (45) as a principal component of fitness for soccer by multivariate analysis of data from a battery of fitness tests and significantly discriminated between levels of playing proficiency. Resting circulatory efficiency of the English League players was also indicated by the low diastolic blood pressures. The slower heart rate allows extended relaxation time during diastole for the pressure to drop below the normal level of approximately 80 mm Hg. The pulse pressure represents the difference between systolic and diastolic pressures and the value of 50 mm Hg for the English League players represents superiority to the normal 40 mm Hg or 42 mm Hg reported for 201 Olympic Games athletes (10).

The maximal heart rates shown in Table 2 are close to the rates expected for nonathletic Caucasian subjects of similar age (5). The indications are that this variable does not increase with training. Some studies have shown a reduction in maximal heart rate as a training effect (27, 56, 59). This has been alternatively

TABLE 2. SOME CIRCULATORY MEASURES ON FIRST-CLASS SOCCER TEAMS

Note: Values are mean $\pm$ S.E. (Standard Error) or mean only.

	Resting Heart Rate (beats/min)	Maximal Heart Rate (beats/min)	Systolic Pressure mm/Hg	Diastolic Pressure mm/Hg	$\dot{V}O_2$ max l/min	$\dot{V}O_2$ max ml/kg/min	$\dot{V}E_{\text{max}}$ l/min
Australian World Cup Team (18)	—	191	—	—	4.26	56.1	—
Dallas Tornado F.C. (41)	50 ± 1	188 ± 2	121 ± 1	77 ± 2	4.42	58.4 ± 0.83	153.6 ± 4.1
English League First Division (43)	48 ± 1	198 ± 1.4	120 ± 2.16	70 ± 2.16	4.82	66 ± 2.7	—
Aberdeen F.C. (58)	—	—	—	—	4.0	57.8 ± 6.5	108.3 ± 16.9
Swedish National Team (5)	—	—	—	—	4.3	56.5	—
South Australian Team (61)	—	175 ± 6.9	—	—	4.67	62 ± 2.1	—

explained as either a manifestation of the difficulty of getting highly trained subjects to operate at maximum in laboratory conditions or to a reduced drive from the sympathetic nervous system to the heart with conditioning (37).

Circulatory recovery from exercise may be very important in soccer, which involves intermittent work periods interspersed with short rests. The Harvard Step test, designed initially for college men and later used in the testing of military conscripts, provides a fitness index based on the effects of a controlled work load on the postexercise pulse rate and on its rate of recovery (14). The test has been widely used in assessing the fitness of sportsmen. Thomas (54) reported a Harvard Index (HI) of 117 for soccer players. This is in close agreement with the figure of 119.5 for soccer players at the Olympic Games (30). The highest value reported for an English League player was 127 (43). According to test norms these values are classed as excellent, though they are considerably less than the 160.2 for Olympic Games marathon runners (30) or the 172.4 and 174.2 indices reported by Cureton (21) for two world record holders in track running.

Hematological Status

Blood hemoglobin (Hb) content is important for endurance sportsmen since it constitutes the oxygen-carrying component of the blood. The Dallas Tornado players had hemoglobin concentrations of 14.6 ($\pm$ S.E. = 0.2) g/dl and 41.9 ($\pm$ S.E. = 0.5)% hematocrit, i.e. the proportion of blood volume occupied by the red blood cells which carry hemoglobin. These values come within the normal range. Brotherhood and coworkers (13) found Hb levels of 14.16 ($\pm$ S.E. = 0.72) g/dl and 41.06 ($\pm$ S.E. = 0.98) g/dl in athletic and nonathletic subjects respectively. Athletes taking iron supplements had similar values to the others. Blood volume and total body hemoglobin (TBH) were on average 20% higher in the athletes than in the nonathletes. This finding confirms the established relation between $\dot{V}O_2$ max with blood volume and TBH in athletes (48).

It seems also that athletes have significantly higher concentrations of 2,3-diphosphoglycerate in the red blood cells. This is an intermediate which affects the affinity of hemoglobin for oxygen and facilitates oxygen transfer to the tissues. The hematological status of top soccer players merits further investigation.

Maximal Oxygen Uptake ($\dot{V}O_2$ max)

Since physiologists (4) began to equate aerobic capacity with physical fitness, $\dot{V}O_2$ max has been the predominant criterion of the condition of the circulo-respiratory system. Superior maximal oxygen uptake values have been reported

among national champions and world class competitors in endurance sports. Outstanding orienteers, cross-country skiers and track middle and distance runners have values exceeding 80 ml/kg/minute (48). The $\dot{V}O_2$ max values reported for soccer players are shown in Table 2. Though in general the observations are appreciably lower than in top class athletes they are greater than the range of 3.10 to 3.69 l/minute or 44 to 51 ml/kg/minute quoted by Åstrand (3) for normal males.

The mean $\dot{V}O_2$ max reported for the 11 members of the Swedish National team was 4.3 l/minute or 56.5 ml/kg/minute (5). The corresponding value for a larger group of 50 top Swedish footballers was 4.2 l/minute or 58.6 ml/kg/minute. The highest value reported was 69 ml/kg/minute. These authors argued that since soccer permits brief pauses between bursts of physical effort, the same level of aerobic power is not required in the players as in long-distance runners, cross-country skiers, or athletes in events requiring continuous long-lasting effort of near maximal intensity.

Soccer players at the Mexico Olympic Games were found to have mean $\dot{V}O_2$ max values of 3.1 l/minute and 43 ml/kg/minute (26), values not representative of highly trained athletic subjects who compete for 90 minutes. These subjects were Ethiopian nationals and probably were not representative of top class professional players. Also, measurements were made at an altitude (Mexico City) which was likely to have reduced $\dot{V}O_2$ max by more than 10% in athletic subjects (8).

Caru and coworkers (15), who studied 95 nonprofessional players aged 14-18, found mean values ranging from 50.2 to 52.3 ml/kg/minute for the various ages. These results were not significantly different from mean values for professedly sedentary subjects of similar ages. Though these young players were reported to practice three times each week as well as compete weekly, there was no indication of the training stimulus or of playing proficiency. When subjects were subdivided into goalkeeper, fullback, halfback, forward, winger, and center forward, the goalkeeper was found to have significantly lower values than all the outfield players. No differences were observed among outfield positions, suggesting group homogeneity at this ability level. Since these players were still at developmental ages it is likely that they had not specialized in particular outfield playing positions.

When English League players were subdivided according to positions in the 4-3-3 team configuration employed, the midfielders had significantly higher aerobic power values than all other positions. The center backs had significantly lower relative values than the other outfield players while the fullbacks and strikers had intermediate values. The goalkeepers had significantly lower values than the center backs (43). It seems that at top level the highest capability for endurance performance is possessed by the midfield players, who must act as linkmen between the defense and the attack.

The Cooper 12-minute run-walk test for distance (19) gives an indirect indication of aerobic efficiency. The Dallas Tornado players averaged 1.86 ($\pm$ S.E. = 0.04) miles which is identical to the mean performance of the Brazilian National Soccer team cited by Raven et al. (41). Reilly (44) reported that running tests had low reliability with professional soccer players when endurance was a factor and concluded field tests in training conditions should not replace physiological measures.

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2. SOCIOLOGICAL AND PSYCHOLOGICAL FACTORS

SOCIOLOGICAL CONSIDERATIONS

Soccer has generally been associated with individuals from the lower of the socioeconomic categories (12, 13). Douglas (13) described English professionals as coming from very ordinary backgrounds, while Davies (12) delineated the occupational and education background of Tottenham Hotspur players. The fathers of the majority of these players were in unskilled or semiskilled occupations while most of the players were educated at Secondary Modern schools. A successful career in soccer can considerably enhance upward social mobility, though social mobility may be incidental to the player's motives. Since middle-class individuals usually have a higher motivation for achievement than the lower classes, membership in the latter is hardly a prerequisite for soccer success (31). As each sport has its own distinct social connotation, the orientation of working-class individuals to soccer participation may be due to interactions of socio-cultural, economic, and psychological factors. Soccer has advantages over other sports in that participation is promoted at an early age among working-class youths, since it requires little financial outlay to practice and acquire the basic game skills.

Similar trends have been apparent in other European countries. Lüschen (24) developed a taxonomy to differentiate sports according to social stratification in the Federal German Republic. Sports were classified according to four groups. Group I (elite) included, for example, skiing and tennis; Group II (upper-middle)

included rowing and riding; Group III (middle) included gymnastics and badminton. Soccer was listed at the bottom of Group IV, which corresponded to the general social stratification, and was designated "the sport of the common man." This helps to explain the enormously popular active appeal of the game. Similar trends were reflected in studies of its passive appeal, the attendance at major European matches being predominantly working class males (1).

This picture may show cross-cultural variations and fluctuations over time with changes in national economic circumstances. In the United States Loy (23) reported that the occupational status of the fathers of collegiate soccer players was lower middle class. Of ten sports examined soccer had the lowest percentage of players' fathers not completing high school. Social mobility, indicated by the difference between the mean occupational prestige scores of the fathers' main job and the players' first job, was greater in soccer than in any of the other sports studied except wrestling. Again, at this ability level the positive relationship between soccer players and rise in social status was demonstrated.

Conventionally it seems that soccer is watched predominantly by the working class and played by individuals largely from working-class backgrounds. From the soccer team's point of view, a relevant consideration is the local support it can generate. It is generally expected that teams get better results when playing at home than when playing away. This expectation is usually borne out in analysis of League match results. This is attributed to the vocal encouragement of home supporters, since the beneficial effects of shouting and cheering are well documented (e.g. 18). This effect of an audience in enhancing performance is known as social facilitation and the stimulus would normally be greater for the home side.

One effect of a crowd is to generate anxiety in the performers. The relationship between prematch anxiety and team performance was studied throughout a complete season in one English League team (29). The mean increment in resting heart rate immediately prior to going onto the pitch was used as the index of anxiety while an arbitrary 10-point scale shown in Table 3 was used for grading gross team performance. This scale introduced a weighting for the margin of victory and for the venue. Anxiety levels were not significantly correlated with performance, but seemed to lag behind previous results in that a series of poor results brought an increase in team anxiety which was in turn reversed by a winning result. Anxiety increased at matches affecting the club's League status where financial incentives to win were offered. Anxiety levels did not correlate with spectator attendances but were significantly greater when playing at home than when playing away (34). Since at their home ground players perform in front of spectators likely to be highly critical of poor play this result is understandable.

The influence of certain kinds of social pressures on players is perhaps more amenable to investigation in younger players. Graf (17) applied the Kinder-Angst test to 100 young club players to measure their anxiety levels. Results showed how parental fears and emotions affected the boys in their play. Some reports (e.g. 39,

TABLE 3: SCALE FOR GRADING GROSS TEAM PERFORMANCE

Result	Venue	Margin	Points
Win	Away	> 1 goal	10
Win	Home	> 1 goal	9
Win	Away	1 goal	8
Win	Home	1 goal	7
Draw	Away	Draw	6
Draw	Home	Draw	5
Lose	Away	1 goal	4
Lose	Home	1 goal	3
Lose	Away	> 1 goal	2
Lose	Home	> 1 goal	1

42) indicated that performances of individual professional players do suffer as a result of unfavorable criticism from spectators and journalists. Further investigation is needed to clarify the interaction between individual and team performances on the one hand and audience reaction to that performance on the other.

PERSONALITY

There is an abundance of literature on the assessment of personality traits of sportsmen. Ogilvie and Tutko (26) claimed to have identified personality dimensions which are essential to competitive success. The successful top class competitor is highly driven, dominant, emotionally stable, conscientious, conservative, and realistic. Cratty (9) concluded that athletes are generally high in intelligence, are likely to be extroverted, and to possess stable traits evidencing emotional control and tough-mindedness. Cooper (7) cited evidence supporting in general the notion that athletic ability goes with a greater motivation to achieve, greater social adjustment and ascendancy, and higher emotional stability. The point was underlined that the psychology of team membership may be different in important ways from the influence of physical activity on individuals.

Not only do consistent differences appear in personality traits between athletes and nonathletes and between individual and team sports, but differences between sports have also been reported (9, 19, 21, 27). Most of the personality data obtained from soccer teams has been obtained using Cattell's 16 personality factors (PFs) (6). Kane (20) emphasized that although one can point to personality differences in those who make up successful soccer teams, the variation is not great and a "soccer type" can be described. This type is a "stable, extroverted, tough-minded radical" of good general ability and ruthless efficiency.

Administration of an abbreviated form of the MMPI in nine European countries suggested that certain national characteristics prevailed among the players (4). German footballers tended to be active, aggressive, and dominant. They were more impulsive and had a greater frustration tolerance than the Swiss players who compensated by a higher ability to judge complex behavior in group situations. Italian players followed a pattern similar to the Germans but with a greater deviation from the average profile.

Da Silva (11) put intelligence highest on the list of psychological aptitudes for excellence in soccer. His protracted list of personality requirements was backed by theoretical considerations rather than research. Intelligence is not identical to educational attainment since the social environment of young footballers and the implications of an early apprenticeship in the professional game may militate against maximum educational achievement. Brazilian professional players were higher in intelligence than eight other skilled or semiskilled occupational groups (5).

Since personality is determined by genetic factors but modified by environmental experiences, it is possible that competitive results and experiences may alter personality characteristics. It is well established that competition brings about a shift in mental states or short-term factors (9, 30, 34). It is not so clear to what extent traits or relatively enduring mental characteristics are subject to fluctuations. One English League team (10), during a particularly poor season, was found to have personality profiles which did not correspond to that expected of soccer teams as identified by Kane (20), in that its subjects lacked emotional control and security. When relegation to an inferior division of the League was avoided at the end of the season a significant increase in dominance and a significant reduction in apprehensiveness was found. These changes were in the direction of the expected profile of a successful team. It seems that lack of team success generates psychological problems within its members which require specific coaching techniques.

Several reports (e.g. 25, 40, 41) demonstrated that emotional stability is a necessary condition for success in top level sport. It seems that talented neurotic athletes may opt out of top level competition and so display a selective mortality (25). Such individuals with labile behavior typically have short professional soccer careers. Yaffe reported a number of case studies in soccer (42) which suggested that by application of mental training techniques, developed originally in clinical and experimental psychology, those gifted players who are emotionally unstable need not be lost to the game. Techniques described included:

1. Autogenic training to systematically modify activation levels pre-match
2. Assertive training to restore self-confidence in players who had apparently lost their edge
3. Behavior modification to reduce gross acts of aggression during match-play

An alternative approach to the study of personality is to measure personality orientation rather than personality traits. The orientation inventory (3), which measures the self-, interaction-, and task-orientation of personality has been frequently used to analyze formal work groups (14). A task-oriented individual concentrates on getting the job done and may ignore different ways of doing it that different individuals might have. The self-oriented person is concerned solely with his or her own performance. He or she is likely to be dominating and heedless of the needs of others and is often rejected by others. The interaction-oriented individual puts most emphasis on keeping the group together in harmony and may facilitate or impede a group task.

When the Orientation Inventory was administered to 17 of the 22 English League First Division teams (8), the more successful teams were found to have significantly more players who were high in self-orientation and low on both interaction- and task-orientation. It seemed that those players who were self-oriented needed enough interaction orientation to be able to hold the team together. When players were divided according to positional roles, the highest values for self-orientation were found in the strikers and the lowest in center-backs. A certain amount of freedom from group influence appears to be demanded of goal scorers while group-directed stoicism is required of central defenders. The results suggested that the differentiated task functions within a team may determine the type of personality orientation most suited to particular playing positions.

GROUP DYNAMICS

Elias and Dunning (16) concluded that within sociology conventional small-group theory has nothing to offer in the analysis of soccer. Match play constitutes a type of group dynamics produced by controlled tensions between two teams. At any one moment the decisions and moves of individual players depend on the fluctuating configuration of the other players, embodying a controlled tension. Concepts such as "interaction" of the type that occurs between two individuals are likely to be misleading. They suggested a configurational approach to the study of soccer in which attention is focused not on the dynamics of one side or the other but on both together as a single configuration in tension. This approach, though theoretically interesting, has not yet produced any recommendations of use to soccer practitioners.

A more fruitful avenue of research may be the study of integration of individual members within a team. Within the soccer world an association is frequently postulated between the number of players representing a team in a season and overall performance throughout the season. In other words, it is generally believed

that greater team successes occur concomitantly with stability in team composition. A study of the German Federal League teams reported that a constant line-up helped players to know each other, to develop mutual bonds and anticipate each other's behavior. A significant positive correlation ($R = 0.62$) was found between measures of team success and the constancy of team line-up. The successful teams introduced new players less frequently than the unsuccessful teams (43). In a study of an English League First Division team (35) the number of players used per season was found to correlate significantly with the team's annual final League position over the 22-year period from 1953 to 1975 ($R = 0.67$). Whether success is due to improved team cohesion and tactical organizational efficiency, or to avoidance of injury in key positions, or to superior group morale with fewer changes in personnel, is a matter of surmise. What is clear is that frequent changes in playing personnel militate against team efficiency.

Sociometry provides a convenient method of establishing the degree of positive and negative relationships between individual members of a team. This technique would be of value in identifying imperfect interpersonal relationships which could then be corrected in the course of coaching. From a study of four Polish League teams (44), it was concluded that the players of the better teams showed higher mutual acceptance both in terms of personal bonds and playing skills. Low indices of group cohesiveness were found in the two teams with deteriorating competitive form. Goalkeepers in all teams had high results for isolation and rejection, this finding being apparently connected with the position's specific role with the goalkeeper having frequently to act single-handedly against the opposition.

In Hungary an adapted sociometric scale was administered to a top team (Ferencváros) in the First Division and to a bottom team (MTK). Positive relationships existed among many of the Ferencváros players while in MTK there was a number of solitary players (41). It was reported that players friendly with each other passed the ball to each other more frequently than to those with whom they were not friendly, and when a player was under pressure in a match he tended to pass only to a player he liked. Yaffe (43) concluded that friendship was the most important factor in passing the ball, though the available evidence was hardly sufficient to substantiate his generalization. Though it is clear that harmony between members is associated with team success, it is not established whether this is the result or the determinant of that success.

Eberspacher and Essing (15) studied 13 German League soccer teams by administering a sports specific sociometric questionnaire to 237 players. Questions were related to socio criteria, psycho criteria and leadership qualities. Factor analysis of results produced three social evaluation dimensions:

1. Play-success oriented interactions, referring to the task structure in a team
2. Social-emotional interaction, referring to the actual sociometric structure which could be described as friendship patterns

3. Leader-oriented interaction, referring to leader influence on the team members.

These dimensions present a reference system to individuals in an interacting small group like a soccer team. They regulate the social structure of the group, in particular its action, cognition, and moods.

Da Silva's (11) description of requirements for soccer leadership was in somewhat similar terms. Socioemotional leadership calms the team; the morale leader maintains the enthusiasm of members; the action leader specializes in counter offenses when the team is losing and is characterized by aggression; the commander instructs on tactics and changes in tactics and is the alter-ego of the coach during match play; the representative leader or captain should impose by presence rather than by word. In summary, soccer dynamics during competition requires two types of leadership. The commander or leader in the field improvises new strategies while the other tranquilizes his teammates and helps them control emotions. The ideal captain would be capable of both functions. Since both are enhanced by experience, it is not surprising that successful team captains are generally experienced as well as skillful players. It is recognized that no one leader can best build morale under all conditions (33).

Cooper and Payne (8) analyzed the orientations of team leaders in English League teams. Leaders consisted of managers, coaches/trainers, and captains. The orientations of managers, who had the most formal authority in the team, were unrelated to the effectiveness of their teams. In sharp contrast, coaches' and trainers' task-orientations showed a definite association with team performance. The manager in English League football is concerned mainly with administration and strategy whereas coaches and trainers spend most of their working time with the players. It seems that a leader's task-oriented behavior can influence subordinates only if the leader has reasonably close and frequent contact with those subordinates. The concept of a track-suited manager is supported by these results.

PSYCHOMOTOR CHARACTERISTICS

Simple reaction time gives a measure of how quickly a subject can respond to a stimulus in the immediate environment. This ability is predominantly due to heredity but deteriorates with age. Reaction times of English League soccer players to a visual stimulus were found to be faster than the normal values (29) and similar to reaction times of track and field athletes (35). This result agrees with values for a range of sportsmen (22) and the observation of many investigators that athletes are superior to nonathletes in this measure (20, 22). No significant differences were found between the First Team and the Reserve Team squads nor between goalkeepers and outfield players. The apparently rapid responses of

goalkeepers in competitive conditions can be attributed to their trained ability to anticipate the attackers' play from antecedent cues. This ability to correctly predict opponents' maneuvers and to select the appropriate response rapidly from a large array of possible ones is a recognized hallmark of the skilled performer (37). The highly skilled player has the ability to read and interpret complex situations quickly and to initiate decisive action. The faster the simple reaction time of the individual, the quicker will be the responses to complex situations. It will also give him an advantage in short sharp movements.

Whole body reaction time (WRT) of soccer players was studied by Togari and Takahashi (36). No differences were found in simple WRT between regular and substitute players but the regular players had the faster choice WRTs. No differences were observed between any of the various playing positions although goalkeepers were generally faster to react in choice WRT. This superiority is likely to be largely a product of training specific to that position.

Limb movement time should be an important attribute of the successful soccer player. This measure is independent of reaction time and is quicker in athletic subjects than in nonathletes. It does not, however, appear to have been studied in soccer players, so that there is as yet no indication as to whether it discriminates between different levels of playing proficiency or different positional roles in the game.

Singer (33) recognized the importance of excellent peripheral vision in soccer. He cited Dembowski's norms of 84.5° for athletes compared with 71.25° for nonathletes. Visual acuity and depth perception are additional aspects of vision important for soccer. The need for excellent dynamic visual acuity would apply especially to the goalkeeper because of the correlation of this function with ball catching (32). Despite the obvious relevance of visual characteristics for success in soccer play, they do not seem to have been studied in any great detail.

The field dependence/independence construct (38) regards perceptual ability as a continuum whose ends represent two contrasting modes of perceiving. This refers to the perception one has of oneself in relation to the surrounding field. Kane (21) postulated that field dependency may be an advantage in performance of team sports in which the performer must relate the skill to the environment. This involves the ability to discriminate among complex visual stimuli. The hypothesis was not supported by the experiments of Barrell and Trippe (2) who found that 30 English League First Division players were not significantly different from a control group in field dependency. Pargman and coworkers (28) reported a relationship between visual disembedding and injury in American football players. Individuals who have developed the capability to extract meaningful cues from their surrounding visual fields are less likely to get injured. No relationship was apparent between injury and field dependence as measured with a standardized rod and frame test.

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3. DEMANDS OF COMPETITION

INDIVIDUAL WORK RATE

The energy cost of running a given distance is related to mechanical work output and is independent of running speed. It follows that the work rate of individuals in soccer can be indicated to a large extent by the total distance covered during a game. The distance covered is representative of the severity of the work and also individual contribution towards total team effort. Large discrepancies exist in published data for total distance covered in soccer match play. Invariably, a description of the methodology for measuring distance is not offered with these reports.

Wade (72) reported a range of 1,600-5,486 m for distance covered during 90-minute competition. The total distance covered at speed was attributed a range of 229-1,829 m and walking or jogging pace a range of 1,371-3,658 m. No indication was given as to how these figures were derived. At the upper extreme Vinnai (70) cited Russian reports of footballers covering up to 17 km during a match, though no reference was made to methodology.

Manchester City outfield players were reported to have covered an average 4,886 m (range 3,722-6,428 m) over one competitive game. Mean value over four games was 4,834 m. In this study values were obtained in units of 5 yards by a group of observers employing subjective estimates of distances. The authors claimed a high reliability coefficient ($R = 0.61$) for their technique but made no

attempt to establish objectivity (32). The observers might have consistently overestimated or underestimated distances, the latter being the more likely.

Zelenka et al. (82) referred to Seliger's observations that a center forward covers 11.5 km during a match. In their review of other studies in training and in matches in Czechoslovakia they concluded that footballers run more than 6 km in a match mostly in 5-10 m runs. It was not disclosed how distance was estimated.

The disparity in data on work rate during competitive soccer is highlighted by the observations of Saltin (personal communication August 16, 1973). Nine soccer players were studied by taking a movie of each player for a 3-minute period. Three matches were filmed, movements of players were penciled in on playback on a white paper screen and distances determined from this. Mean distance covered was 10.9 km, 37% at walking pace and 20% at maximal speed.

It should be apparent that figures for distance covered by footballers during match play should be treated cautiously unless details of methodology are presented. Thomas and Reilly (68) devised and validated a motion analysis method of quantifying work rate during soccer competition. The technique required monitoring of the extent and intensity of discrete movements of individual players. A coded commentary on the behavior of one player per game was performed on 51 occasions using a tape recorder and stopwatch. Movement was divided into walking, backing, and running; running was subdivided into three intensity levels of jogging, cruising, and sprinting. The distance of each discrete movement was estimated in 1-meter units from an elevated position in the stand directly over the halfway line using a number of cues on the playing pitch and along its boundaries. The incidence of jumping, tackling, and kicking; the durations of stationary rest pauses; and the distances covered in possession of the ball were also recorded. The methodology was validated by concurrently filming one subject and obtaining distance measures from a film record of one complete game. Results closely corresponded and the measurement error was established at 1%. Table 4 shows distances covered according to types of activities and frequency of movement activities per game in outfield players.

The overall distance covered by outfield players during competition ranged from 7,069 to 10,921 m with a mean of 8,680 m. Of this, 36.8% was covered jogging, 24.8% walking, 20.5% cruising, 11.2% sprinting, and 6.7% backing. The proportion of the overall distance covered in possession of the ball ranged from 4% to .26% in outfield players. The behavioral profile included more than 900 discrete activities per player per game. An average game involved 43 pauses and cumulative time standing still was 143 seconds per player per game. Results indicated the frequent alteration in movement intensities and the infrequency of rest pauses in top class play. The mean distance per discrete activity was 10 m, while activity changed on average every 5 seconds. Three walks were taken every minute and a stationary rest pause of 3.8 seconds every 2 minutes (68).

TABLE 4. DISTANCES COVERED ACCORDING TO TYPES OF ACTIVITIES AND FREQUENCY OF MOVEMENT ACTIVITIES PER GAME (N = 40)

Activity	Overall Distance (m)		Frequency	
	Mean	SD	Mean	SD
Jog	3187	746	239	48
Cruise	1810	411	114	16
Sprint	974	246	62	15
Walk	2150	471	308	49
Back	559	247	120	37
Aggregate	8680	1011	843	—
Distance in Possession of Ball	158	85	—	—

Note: Values are averaged over all players not in the goal position. After Thomas and Reilly (68).

Work rate was significantly higher in the first than in the second half. This decrement may represent a fatigue effect. It is also possible that the usual reduction in uncertainty of the result as the match progresses effects a change in work rate. Saltin (55) reported a similar reduction in the distance covered between the first and second periods for nine Swedish footballers. The players with the lowest glycogen content in their thigh muscle at the start of the game covered 25% less distance than the other players. An even more marked difference was observed for running speed. The players with low glycogen content covered half the total distance walking and 15% at maximal speed compared with 27% walking and 24% sprinting for the high glycogen players.

Saltin concluded that initial muscle glycogen appears to be important in playing soccer. Saltin and Hermansen (56) made recommendations for augmenting local muscular stores of glycogen. Their method involves manipulation of both diet and exercise for a 7-day period prior to competition. Their procedures have been generally adopted by distance runners but are not directly applicable to top soccer players because of the usual hierarchy of objectives in weekly training and the frequent occurrence of midweek competition. Ingestion of a glucose syrup solution prior to endurance work is accompanied by greater efficiency during exercise and recovery, manifested in lower heart rates and higher blood glucose levels (65). Individual response curves suggest that the solution could be taken both prior to play and during the interval. Muckle (38) reported the beneficial effects of glucose syrup ingestion in an English League Second Division team (Oxford United) in

play performance and game results. Taking glucose syrup increased the individual's direct involvement in play and improved the team's ratio of goals scored to goals conceded. The positive effects in other endurance activities have been reported by several investigators (e.g. 25, 64). There is evidence of glucose syrup ingestion affecting soccer skills beneficially in 5-on-a-side soccer (28). These results support the use of glucose syrup ingestion before the kickoff and during the intermission. Probably the most important value of oral glucose administration during exercise is to maintain blood glucose concentration vital for brain metabolism.

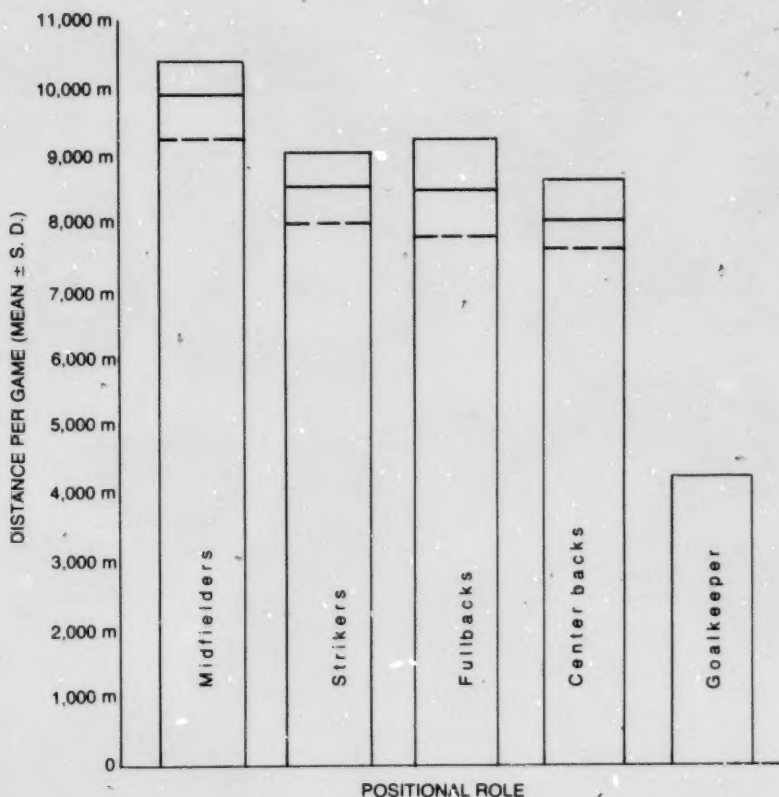


Figure 1. Work rate (mean $\pm$ standard deviation) per game according to positional roles. After Reilly and Thomas (49).

TABLE 5. DISTANCES COVERED IN VARIOUS POSITIONAL ROLES
ACCORDING TO TYPES OF ACTIVITIES AND FREQUENCY OF MOVEMENT ACTIVITIES PER GAME.

	Activity	Distance (m)		Frequency of movements	
		Mean	SD	Mean	SD
MIDFIELD (N = 11)	Jog	4042	540	288	30
	Cruise	2159	314	118	20
	Sprint	1063	162	68	15
	Walk	2034	368	315	51
	Back	507	295	106	38
	Aggregate	9805	787	895	—
FULLBACK (N = 8)	Jog	2907	431	226	50
	Cruise	1588	281	109	15
	Sprint	787	284	52	11
	Walk	2293	388	331	28
	Back	670	208	138	38
	Aggregate	8245	816	856	—
STRIKER (N = 14)	Jog	2769	616	210	32
	Cruise	1752	437	114	14
	Sprint	1068	252	65	17
	Walk	2310	558	304	58
	Back	498	167	117	31
	Aggregate	8397	710	810	—
CENTER BACK (N = 7)	Jog	2908	348	225	37
	Cruise	1596	254	110	14
	Sprint	829	113	59	10
	Walk	1774	316	276	25
	Back	652	305	131	41
	Aggregate	7759	521	801	—

Note: After Reilly and Thomas (49).

Mean values for work rate in a team may disguise demands on particular playing positions. Figure 1 summarizes variations in work rate according to the different positions in an English League First Division team (49). Table 5 shows distances covered in various positions according to types of activities and frequency of movement activities per game. The team studied employed a 4-3-3 formation with positions classified as goalkeeper, fullback, center back, midfielder, and striker.

The goalkeeper covered 3,972 m during competition, 10.3% of this in possession of the ball. Jogging comprised 27.4% of the distance covered, walking 33.7%, cruising 12.5% sprinting .8%, and moving backwards 25.6%. Sprints were infrequent, amounting only to 7. Distance moved backwards was 1,020 m, a distance exceeded in 40 outfield players on only one occasion. Time spent stationary amounted to 776 seconds, comprised of 252 separate pauses. There were 957 discrete movement activities. Frequency of jumping to play the ball was 13, and the ball was received from his defense on 24 occasions. A total of 17 shots at goal by the opposition were off target. The ball was kicked out by this player on 59 occasions and thrown out 8 times. The pattern of movement and activity indicated greater direct involvement by the goalkeeper in play than any outfield player.

The critical demands on the goalkeeper may be disguised in these figures to some extent. The high proportion of distance covered in possession of the ball is due to a number of factors. When in possession of the ball the goalkeeper does not run the same high risk of being dispossessed as outfield players and can hold it longer. He usually takes the ball to the edge of his area before releasing it. He may carry the ball across his area to retain it longer for tactical purposes. Reception of the ball from his own defense amplifies his work rate with only marginal increase in skill requirements. When there is no direct threat to his goal he does not usually stand still. This involuntary movement may represent an attempt to maintain arousal and assist performance and in certain conditions to keep warm. There is ample evidence that capacity for action is reduced by periods of inactivity (11), and in tasks requiring dynamic visual acuity performance is facilitated by a fore-period of light exercise (76).

A considerable proportion of the distance covered by the goalkeeper is only indirectly imposed by the game demands. In addition to the skills specific to his position the goalkeeper needs great muscular power for successful jumping and for short explosive efforts. This concords with the high scores in vertical jump and standing broad jump found in four goalkeepers during laboratory tests (46). It seems jump endurance, speed endurance, and aerobic power are not critical for this position, and that the goalkeeper's fitness training should employ separate regimes from the outfield players.

Among outfield players midfielders were found to cover significantly more distance than any other positional group. Center backs covered the least distance ($7,759 \pm S. D. \pm 521$ m), though the difference between the center backs and fullbacks was not significant. This was possibly due to the large variance in the overall distance covered by the fullbacks, which ranged from 7,324 to 10,023 m. The lowest value for a fullback was recorded when the subject was not directly confronted by an opponent because of the opposing team's unorthodox formation, while the greatest value was observed in a player who had in the previous season and in the subsequent season played in midfield.

Center backs were observed to cover proportionately more distance moving backwards than the other outfield players (46). The frequency of jumping in center backs ($20.4 \pm \text{S.D.} = 6.4$) and in strikers ($19.6 \pm \text{S.D.} = 9.8$) was significantly greater than in midfielders ($10.3 \pm \text{S.D.} = 4.15$) or fullbacks ($11.1 \pm \text{S.D.} = 4.5$). This rate of jumping would not suggest that specific jump endurance training is needed for any position. The pace of walking was slowest among outfield players in center backs. The proportionate distance covered in possession of the ball was least in this position and greatest in strikers. Whereas work rate with its implication of an endurance determinant may not be a requirement of center backs, anaerobic power might be. The winning of the ball in the air is a critical defensive need for which explosive effort is demanded. The ability of the center back to win aerial possession can also be exploited in specific attacking maneuvers, for example, in corner kicks and free kicks.

The profile of midfielders contrasted with that of center backs in terms of jumping frequency and overall distance covered. The midfield player who covered the most distance in a game rested for only 11 seconds during it. A high work rate is demanded of players in this position, since they act as linkmen between defense and attack and contribute to both of these functions. A significant positive correlation was found between distance covered per game and $\dot{V}\text{O}_2$ max, indicating that high aerobic capacity is critical for playing in midfield (49). Midfield players were seldom required to win aerial possession and great explosive leg strength and anaerobic power might not be as critical here as in the center back position.

Fullbacks and strikers are intermediate between the midfielders and center backs in terms of work rate (49). The variability in total distance covered in a match by fullbacks probably reflects the greater flexibility players have in this position. Between games the fullback may oscillate from a defensive function similar to the work rate profile of the center back, to an offensive function linking with strikers in overlapping moves and a corresponding work rate profile close to that of the midfielders. Fullbacks are not, however, typically required to win aerial possession and this is reflected in their low jumping frequency. Though the frequency of sprinting is less than among strikers and midfielders the variability advises that speed training and speed-endurance training should not be neglected. The mean frequency of sprinting among outfield players of once every 90 seconds suggests that both types of training are recommended for all outfield players. This is especially so since the acyclical nature of the game implies that in crucial periods of play the demands may be more severe than the mean frequencies indicate.

In general, 98% of the total distance covered is without possession of the ball. The vast majority of movement is concerned with movement off the ball either in attempting to dispossess the opposition or in assuming positions of optimal strategic benefit when teammates have possession. The maximum contribution in work rate must to an extent be determined by the aerobic power. It follows that

high aerobic power is desirable in outfielders, especially in the positions where movement activity is flexible, in midfield and fullback.

Work rate may not be a critical requirement with teams appreciably different in basic soccer skills. The more skillful players may not need to achieve the work rate of their more poorly equipped opponents because of the advantage their skills superiority gives them. Within English League First Division teams no significant difference was found between different teams nor between home and away playing conditions (68). Work rate at three international matches conformed to the pattern of the top English League teams' behavior. It seems that at this level of topflight play where skill levels are relatively evenly distributed between teams, work rate is one highly important aspect of performance.

PHYSIOLOGICAL DEMANDS

The severity of exercise is validly indicated by the level of oxygen consumed or energy expended (5, 15, 20), and is classified accordingly. Since there may be a large variance between individuals in maximal oxygen uptake $\dot{V}O_2$ max, the relative load seems more important than the absolute level of oxygen uptake (5). In many tasks measurement of oxygen consumption is impractical due to interference with the exercise being monitored. Nevertheless some investigators have measured oxygen uptake in soccer players wearing respirometers during casual games (20). In other cases the oxygen consumed has been estimated from heart rate measures monitored by means of radio telemetry (50). The usual procedure is that energy expenditure for a period of time is obtained by using the mean heart rate for the corresponding period and referring to the individual's regression line for the energy expenditure corresponding to the heart rate established under laboratory conditions (4).

In these cases results have been extrapolated to competitive soccer to state the demands of the game. The assumptions were that wearing respirometry equipment didn't affect the performance studied and that a model game reproduced the stress of competition. Reilly and Thomas (50) studied the validity of simulated soccer competition by comparing individual work rate under simulated and actual match play. They concluded that simulated competition in their investigations presented the physiological strain of match play. These investigators then described the demands of the game from heart rate measures. This method of predicting energy expenditure from heart rates has been employed to estimate the energy cost of a number of selected sports by other research workers (e.g. 62).

Reported data for energy expenditure in soccer show large variations. Durnin and Passmore (20) quoted a range of 5-12 kcal/minute for the energy requirements of soccer. The authors concluded that few players expend 600 kcal in a soccer

game and many much less. These figures are likely to be underestimates since the subjects were university students kicking a ball about a pitch and wearing respirometers. Covell et al. (16) reported a range of 5.2-10.6 kcal/minute, their subjects also being undergraduate students. Muckle (38) gave an estimate of 800-1,200 kcal expended per match, but no indication of how this estimate was arrived at. Seliger (57) gave a value of 0.18 kcal/kg/minute as the energy demand of playing a game, amounting to 12.6 kcal/minute for 70 kg individuals. His subjects (mean age = 21.5) were examined in a model game lasting 10 minutes. According to Yamaoka (81) the excess cost of 90-minute soccer play over resting metabolism was 588 kcal. Energy expenditure for the game was 696 kcal when 1.2 kcal/minute was included for basal metabolism (20). Relative metabolic requirements of the energy demand relative to resting metabolic rate were reported as 1 or 2 times for the goalkeeper and 7 to 9 times for other players. These calculations were based on the duration and speed of movements during the game and were likely to represent underestimates. Also, studies of Japanese subjects of undefined skills may have dubious application for top class soccer.

In First Division English League players it was calculated from heart rate data that the energy expenditure during competitive soccer was 16.4 kcal/minute (50). The calculated rate of energy expenditure for 21 outfield players was 17.4 ($\pm$ S.D. = 0.9) kcal/minute and for two goalkeepers 4.5 and 5.25 kcal/minute. The outfielders were estimated to be working at close to 75%, while the goalkeepers were working at below 50% of their aerobic capacity. These values indicate that at high levels of playing proficiency soccer is comparable in intensity with swimming, skiing, and boxing (20).

Apart from its use as a predictor of energy expenditure, the heart rate can be used on its own as an indicant of the physiological strain incurred in the organism. The heart rate is a suitable indicant of the intensity of physical exertion as it is at once an expression of the total load imposed on the body (52). One classification of the severity of work is based on the proportion of the difference between resting and maximum heart rate taken up by the cardiac response to work. The result is expressed as a percentage coronary challenge (27). The classification of work loads from light to unduly heavy devised by Christensen (15) allows work to be graded from the level of oxygen consumed, energy expended, or the heart rate or body temperature reaction. Because athletic subjects have higher aerobic capacities than nonathletes, the heart rate scale would be more appropriate for evaluating strain in sport than the oxygen consumption scale.

Mean heart rate during the 10-minute model game studied by Seliger (56) was 160 ($\pm$ S.D. = 14.4) beats/minute while maximum heart rate was 166 ($\pm$ S.D. = 13.6) beats/minute. This level was equivalent to kayak paddling (mean heart rate 166 beats/minute) but higher mean values were found for basketball (172 beats/minute) and ski running (180 beats/minute).

Value for Czechoslovak soccer was reported in another publication (58) to

be about 165 beats/minute. The result for English League professionals (49) over more extended periods of play was 155.6 ($\pm$ S.D. = 8) beats/minute. When the outfield players only were included in the analysis, the mean heart rate was 157 ($\pm$ S.D. = 7) beats/minute. Mean heart rate of two goalkeepers during "games" was 123 and 126 beats/minute. According to Harrison and Reeves' (27) criterion, soccer constituted a 68% coronary challenge to outfield players and a 51% coronary challenge to goalkeepers.

Agnevik (2) reported a mean heart rate of 175 beats/minute during a major match in one of the top players in the Swedish team. With the exception of some brief periods the heart rate was kept well below the player's maximal rate of 189 beats/minute. Periodic rest pauses allow the blood to remove lactate accumulated within working muscles as a result of anaerobic glycolysis. At the end of a match blood lactate values of 11 mM may be fairly common though values up to 16 mM have been measured (8).

These results indicate that soccer is very heavy work according to the normal systems for classifying physical work. Though these systems may have limited application to top class and professional sport, especially where activity is intermittent, the obvious implication is that this game does place a high degree of strain on the heart and the oxygen transport system. The clear implication is the need for appropriate endurance training to meet these high demands.

PSYCHOLOGICAL DEMANDS

The psychological demands of soccer can be viewed in three main ways. First, each impending game may be seen as producing its own specific emotional strain in the organism, reflected in prematch anxiety. Second, the intracompetition stress may be reflected in behavioral aspects, for example, increased aggressiveness or a propensity to engage in conflict situations. Finally, chronic emotional strain resulting, for instance, from a busy and prolonged competitive period may bring its own specific psychological wear and tear. In this case the whole team might easily be affected.

The various methods available to research workers to monitor anxiety prematch have been reviewed elsewhere (46). These include behavioral indicants like hand tremor (26), behavior observation (12), subjective excitement scales (23), and adjective checklists (48). Physiological measures used in studies of increased activation induced by stress include muscle tone and autonomic activity (74), blood pressure (33), skin conductance (13, 33), and catecholamine output (6, 21). In his discussion of psychological stress at Olympic Games, Shephard (60) equated the acceleration in heart rate prior to competition with the anxiety reaction.

This is a valid measure if there is no preceding exercise (53). Emotional tachycardia has been employed in studies of stress in public speakers, in television producers (14), and in aircraft pilots (10), as well as in sportsmen.

An anticipatory heart rate of 200 beats/minute was found in a world-class downhill skier prior to starting his run and a similar rate was recorded in a girl at a pop concert (7). Rates exceeding 200 beats/minute have been found in racing car drivers awaiting the starter's flag (64). Carruthers (14) observed rates of 150 beats/minute in a television reporter during a live performance and rates found in public speakers were of a similar order of magnitude. Female track runners had mean values of 138 beats/minute, or 66 beats/minute higher than resting rates, 30 seconds before the beginning of their runs (61). Values for other sports are shown in Figure 2. Soccer players (63) with mean rates of 87 beats/minute or 39 beats/minute faster than basal heart rate had higher values than American footballers, but lower levels than water polo players (24) or wrestlers (30). These comparisons cannot validly represent a League table of emotional strain because of differences in methodology and competitive levels as well as the inclusion of team and individual sports of varying durations. The data for soccer were obtained on all players in an English League professional team over 48 games in the 5-minute period before going onto the field of play. According to the tachycardia these subjects demonstrated relatively moderate levels of emotional strain. Results showed individual differences as well as other significant trends.

The highest values were consistently found in the goalkeeper with a mean rate of 111 beats/minute. This was attributed to his crucial role in defense since an error on his part bears a likelihood of conceding a goal. No significant differences were apparent between any of the outfield positions. Individual values were highly reproducible between games in regular first-class players. A first competitive appearance of the season produced significantly elevated individual values, a similar trend being found in players returning to the team after injury. It seems that on these occasions players do need specific coaching to help allay their worries about their physical condition and preparedness. Substitutes had significantly lower levels than selected players, the mean difference being 17 beats/minute. The gradual buildup of anxiety was apparent in the increased heart rate in all players over the hour prior to kickoff. Individual differences were apparent in the slope of this increase. The relationship between the individual anxiety reaction and performance is complex and does not permit easy generalization. A positive relationship between anxiety and injuries in soccer has been reported (67), the more anxious and apprehensive individuals tending to be injured more frequently. The reason was tentatively attributed to a lack of commitment in tackling in apprehensive players. The effectiveness of specific coaching techniques to assuage anxiety in reducing injuries and improving performance has not yet been clearly demonstrated.

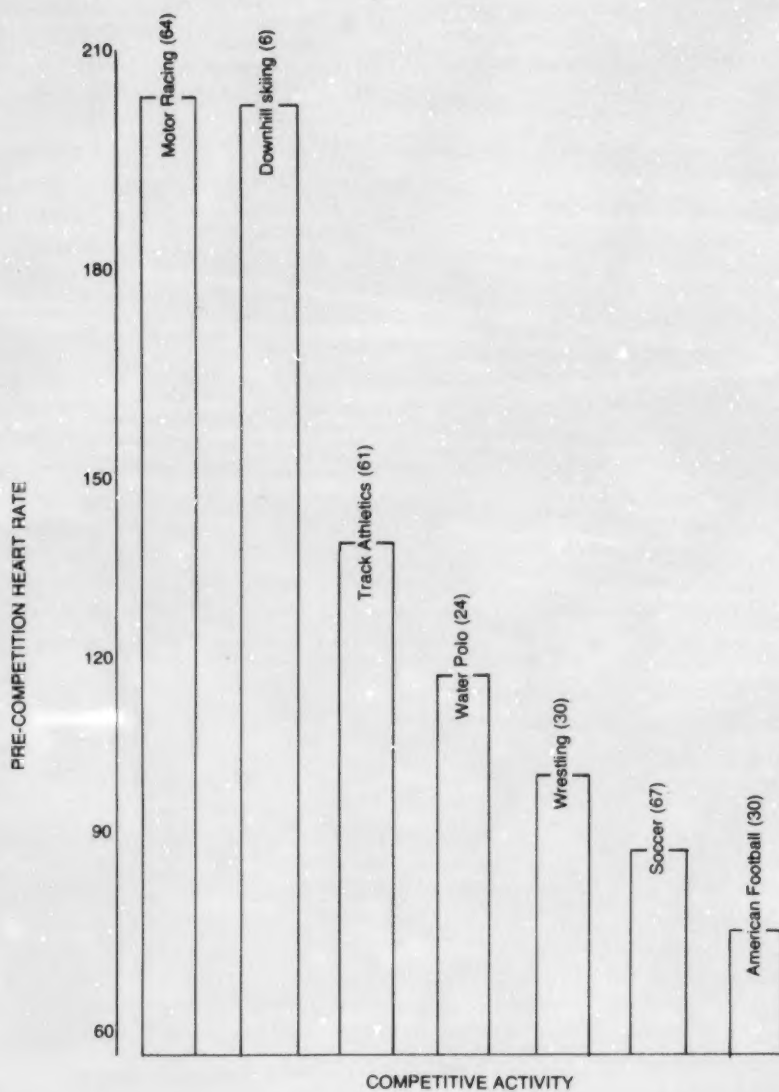


Figure 2. Precompetition heart rate according to competitive activity.

Welford (75), in a review of the relevant literature, concluded that stressing agents which increase arousal — a concept that can in broad terms be equated with Shephard's (60) "anxiety reaction" — could be expected in mild degrees to improve performance and in more severe degrees impair it. This is illustrated in the inverted U-shaped curve shown in Figure 3. The curve indicates that performance is optimal at an intermediate level of arousal. The identification of this optimal level has in practice proved problematical in team games.

The mean level of all 11 players has been taken as the index of team arousal (67). Playing at home caused higher mean heart rates than playing away from home. This was attributed to performing before a more critical audience of home supporters. Cup matches produce higher arousal levels than league games, probably

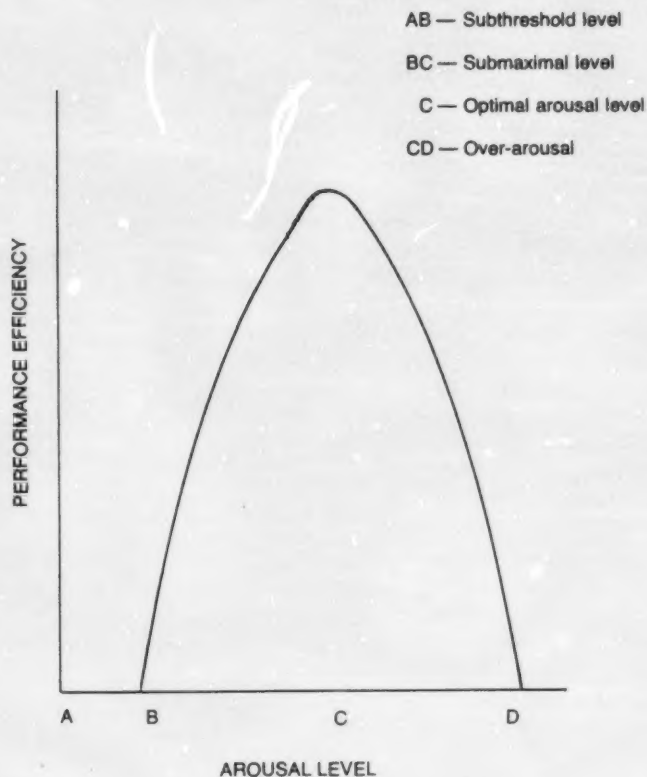


Figure 3. The relationship between level of arousal and performance efficiency.

because of the desperation engendered by knock-out competition. No significant relationships were found between individual prematch heart rates and individual performance as measured by distance covered per game. Team performance measured by match result was not related to overall team arousal levels. Individual differences in the anxiety reaction and the complexity of interrelationships between individual and team performance may mediate against the discovery of optimal levels of arousal for both the team and its constituent individual members. Gross measures like work rate and match result are insufficient on their own as sensitive performance indicants. Yaffe (79) proposed a way of recording player performance which would indicate the quality of interactions between players but presented no data to allow an evaluation of his technique. The methodology included a recording of the frequency, quality, and sequence of passes, tackles, and free kicks. The identification of suitable indices of player performance is a subject that deserves further study.

The psychological stress during soccer competition has been an infrequent subject of thorough investigation. Divic (19) and Yaffe (80) described excessive behavior and aggression in play as one outcome of over-anxiety. Yaffe proposed that gross acts of aggression could be reduced by behavior modification techniques. The contention was that dissent or retaliation are maladaptive learned responses, and because they are learned they can be modified or eliminated if necessary. The aggressive player could for instance be antagonized by confederates in a practice match and then desensitization with relaxation could be used. Since soccer coaches cannot afford to have any of their players sent off for foul play, particular attention to problem members seems desirable. Use of videotape has been suggested to demonstrate undesirable features of play to persistent offenders (80). Additionally, aggression may reflect uncontrolled behavior and is likely to lead to a decrement in the quality of performance since the execution of skills requires a high level of self-control. The competitive and interactive components of soccer provide a basis for the development of frustration which may result in aggressive behavior. Competition stress may also result in lower self-control for many players and so suppress the forces inhibiting aggression. Individuals in a state of arousal such as occurs in soccer competition tend to rely on situational cues and may overattribute the cause of their arousal to the crowd's vocal behavior. This process may mediate subsequent aggressive behavior (35). Aggressive tendencies may also be moderated by situational variables, for example, the location of the game or the importance of the match. The frequency of aggressive acts was analyzed in one study of the Belgian National Soccer League over 240 games. Results showed that the frequency of aggression was greater for visiting team players and for players who were in a losing team. Visiting teams did not behave submissively when away from home, while the aggressiveness of the losing team supported the frustration-aggression theory.

Less aggressive behavior was displayed by the Second Division players than by their First Division counterparts. Since the BNSL has a higher level of professionalism in its First Division, the belief that professional players are disciplined and able to control their emotions to a high degree seems unfounded. Lefebvre and Passer (35) suggested that players might be exposed to learning techniques which increase their tolerance for frustration. Since some degree of frustration is a necessary product of play because of the structure of soccer competition, the aim of which is to produce one winning and one losing team, and since aggressive behavior may be used for expressed tactical purposes by some coaches, instrumental aggression can be reduced only after a consensus is reached to prohibit acts that push the rules of the game to their limits. This eventuality is unlikely while individuals differ as to the precise relative importance they attach to sportsmanship and to winning.

Aggressive behavior may be categorized as either instrumental, the primary goal being the attainment of reward involving neither anger nor frustration, or reactive, influenced by anger with the objective of injuring a perceived enemy. Though instrumental aggression is inherent in competition, features within a contest, such as the outcome (54) or anger due to wounded self-esteem, can promote frustration. Successful sportsmen under stressful conditions tend to be aggressive and highly competitive (45). A comparative study of Scottish Universities rugby and soccer teams indicated that the soccer players were less prepared to employ illegal methods to achieve their objectives (45). The framework of soccer inhibits aggressive behavior to a greater degree, though legal aggressive behavior in soccer can influence following illegal behavior.

A separate consideration is long-term subjection to intense competition. Athletes in regular competition in the presence of great emotional tensions may have reduced nonspecific resistance to stress (59). This may lead to deterioration in vegetative functioning with imperfect appetite and sleep, and ultimately to impairment in the fine motor coordination required in some soccer skills. Dietary, pharmacological, and physiotherapeutic methods as well as improved or varied regimes of training and relaxation, have been suggested as appropriate remedies. English League players showed evidence of habituation to competition stress, with players adapting to the emotional strain of top class play (47). This phenomenon is attributable to a reduction in sensory stimulation and a higher level of stress tolerance accruing from repeated subjection to match play (31). Reduced levels of drive and adventurousness and increased apprehensiveness were reported to coincide with poor midseason results in the same subjects (47). Additionally, increased suspicion among first-team players was reported, a condition that should be expected to precipitate specific coaching difficulties.

Frequent psychological monitoring has been advocated for international standard sportsmen (41, 69) and seems advisable in the case of top soccer players.

Llanos Zuloaga (37) recommended psychological counseling as a necessary part in the training of top players as a result of living with the national Peruvian team for 6 months. Cup competition induces its own type of stress, as does avoiding relegation. Additionally, success in league and cup competitions brings a more cluttered fixture list with reduced recovery time between matches. Andejovic (3) reported that ketosteroid excretion in urine of players resulting from competition stress was double normal training levels. Playing four tournament matches within 10 days caused enlargement of the thyroid gland. Hyperfunction of the thyroid might be a factor leading to aggressive behavior under the tension of competition. Players frequently undergoing psychic stress are susceptible to peptic ulcers, the frequency of ulcer bleeding being greatest in goalkeepers and the greatest frequency among players and coaches occurring when the season is at its peak. More studies are required of the interactions between the frequency, level and type of competition, the psychological stresses induced, and the performance of the team before clear guidelines to soccer practitioners can be laid down.

PHYSICAL DEMANDS

The physical strain imposed on soccer players is manifested in the type and frequency of injuries sustained. Studies of injuries in soccer have invariably involved retrospective analysis of medical records. This approach helps to identify bodily sites of greatest vulnerability and assess risk probability from observed rates of injury occurrence.

Most authorities accept the inevitability of some injuries and generally assign causal phenomena to a number of predisposing factors. Muckle and Shepherdson (39) were resigned to accepting a certain unspecified number of injuries but claimed, "The quantity (of injuries) can be controlled by correct training techniques, warm-up period, a positive approach to balance and nutrition, good personal hygiene, a sound knowledge of each player's weakness and phobias and immediate postinjury care. In fact, good common sense."

Adams (1) provided a hypothetical list of some of the variables contributing to injuries in contact sports: "physical fitness, muscular development, training, balance, skill, assessment of the playing situation, determination, courage, reaction time, playing surface, weather." These are a combination of physical and psychological, internal and external factors. The predictive value of these factors does not seem to have been thoroughly investigated though a positive correlation between anxiety and injury has been reported in soccer players (67), the more apprehensive individuals tending to get injured more often. Davis (18) found

clumsiness and increased liability to accidents in acutely anxious patients preoccupied with their own worries. Because of similar preoccupations, the accident-prone soccer player is less responsive to stimuli arising from the game and may shirk wholehearted commitment to tackle. The instructions of coaches to their players to tackle hard seems to be well founded.

The relative safety of different sports, according to the average days of inter-collegiate play that elapse before an injury is sustained, was assessed in University of Toronto students (40). Though soccer was considered to be a relatively dangerous sport, it was appreciably safer on the criterion used than wrestling, American football, rugby, or basketball. A comparative study of injuries in 696 association and 117 rugby football clubs in the four northern counties of England (73) showed a 20% greater accident rate in soccer, though the severity was greater in rugby where injured individuals were twice as long off play. Fractures and dislocations were twice as common and concussion was also more common in rugby. Of all soccer injuries 65% were to the lower limbs, the corresponding figure for rugby being 35%. More than half of the soccer injuries to the lower limbs were cuts and bruises. Protective padding at the ankles and knees was suggested to absorb impacts, though its acceptability by players hadn't been scrutinized. The authors concluded that a soccer player can expect at least one injury every 2½ seasons. Studies in professional players indicate a much higher incidence of injury.

Adams (1) reported an incidence of one injury for every 12.6 player exposures for Leeds United F.C. An injury was defined as trauma necessitating exclusion from full training for more than one day. Each game was considered to expose 11 players in each team to injury. Using similar criteria to analyze the medical records of another English League club, the injury rate per player exposure was 1/11.7 for the First Division team, 1/26.1 in the "Reserve team," and 1/16.6 in the "A" and "Youths" team. An aggregate of one injury every 16 player exposures was found in the club's professional playing staff. It appears that the superior skill expected in First Division team players does not ensure protection against injury and that the risk factor is greater at the highest level of competition. Here the current risk probability is close to one injury per team per game.

Reports consistently emphasize the greater vulnerability of the lower limbs in soccer compared with the upper body (22). The lower extremity is usually in contact with the ground, is burdened by the rest of the body weight, and is subjected to shear and rotational stresses from extrinsic sources. Table 6 indicates the general agreement among researchers that injuries to joints account for approximately one-third of the total trauma and that the majority of joint injuries are to the ankle and knee, injuries to the ankle being most common. Reimers and Faust (51) showed that 60% of all ankle injuries are caused by forced inversion combined with supination of the foot. A study of loads to be carried by the collateral ligaments in a potential inversion or eversion injury situation indicated that the

load could be reduced by wearing a high type of boot as opposed to a low type (29). It was shown that if, for reasons of mobility, a low-cut boot is preferred, it should allow motion of the subtalar joint to minimize the likelihood of ligamentous injury.

The most frequent site of severe injuries in soccer is the knee, involving on average 56 days off full training (45). Among the Middlesbrough F.C. players muscle and tendon injuries accounted for 43% of all injuries over the 5-year period 1963-1968 (42). Clinical records at Arsenal F.C. over the 6-year period 1960-1966 indicated the commonest lesion occurring in soft tissue was muscle damage (9). Increased muscular strength and avoidance of contralateral imbalance in strength should facilitate a reduction of injuries.

According to Pilgrim (43), injury risk is greatest during the early part of the professional season. Injuries incurred in training in Coventry F.C. were greatest during the preseason conditioning period. This coincides with the most intensive training period of the year when players are still suboptimally prepared for competition. It was recommended that players avoid activities involving vigorous starts and stops and refrain from lengthy shooting practices in the first 10 days of training. Injuries incurred in training comprise only 27% of total injuries in professional players, the vast majority of injuries occurring during competition (46). In a study of leg fractures incurred in soccer, Vittori (71) reported that almost all the injured expended substantial physical effort on the day preceding injury and concluded fatigue to be one of the main predisposing factors. Fatigue resulting from the game itself was discounted since accidents occurred equally at the beginning, the middle, and the end of the game. The practice by secondary school and university students of playing several games a week was deplored. Authorities recognize the foolhardiness of hastily returning to competition after injury and have advocated functional fitness testing during the rehabilitation program to avoid a recurrence (44). With appropriate medical and physiotherapy treatment.

TABLE 6. JOINT INJURIES AS PERCENT OF TOTAL TRAUMA AND SITING IN KNEE AND ANKLE.

Researchers	Joint Injuries as % of Total Trauma	Knee Injuries as % of Joint Injuries	Ankle Injuries as % of Joint Injuries
Thomas and Reilly (66)	34	23	48
Phillips (42)	32	33	52
Bass (9)	35	35	54
Reid (44)	47	27	64

absence from competition can be minimized, the average time to return to full function reported for Arsenal players being 6.6 days for ligament injuries, 4.1 days for muscle strains, and 3.6 days for contusions (78).

Andrejevic (3) described the peculiar morphological changes of the lower limbs, known as "football legs," where deformation results from overstrain during the prepubertal period. For the age group 10-14 years he recommended that soccer games should not exceed 30 minutes each way, while no competition should be allowed for children under 10 to avoid possible harmful influences on the skeleton and malformation of the legs. He recommended that only at 18 years of age should youngsters be allowed to participate in soccer competition for the full 90 minutes.

Larson (34) cited Ivanitsky's findings that long participation in athletics effects a change in the diameter of bones, in their internal structure, and in their length. An example given was that the femur of long-time soccer players is frequently larger than that of the nonathlete. The effects reflect Wolff's law which states that bones will adapt to suit the stresses and strains placed on them. This adaptation is not confined to developing bone.

Long-term joint degeneration in soccer has been the subject of some investigation. A Finnish study of 60 amateur footballers concluded that osteoarthritis seems to be a characteristic of intensive football (63). The diagnostic criteria used in this study were considered dubious by other investigators (1). The incidence of osteoarthritis was examined by clinical and radiological methods in all 51 professional players at Leeds United F.C. and 15 exprofessionals. Osteoarthritis was considered to be probably present in four of the exprofessionals and in none of the active players. A postal survey of 1,490 footballers showed an incidence of 3.2%, suggesting that osteoarthritis is not common in soccer players (1).

Injuries associated with different playing positions have been reported by various authors (3, 17, 77). The goalkeeper is particularly exposed to hand, head, and shoulder injuries from catching, punching, and diving onto incoming attackers. Injuries are more serious in this position than in any other (3). The soccer goalkeeper has no protection for his head and hands, as has his counterpart in hockey, though his injuries occur more often and are more dangerous than those of the hockey goalkeeper. The vast majority of hand injuries in soccer are to the goalkeeper, these largely occurring at lower levels of playing ability from contact with the ball (17). Hand injuries in the other positions occur either in falling on an outstretched hand or in contact with another player.

Defenders are typically involved in accidents in jumping or in tackling to contest possession. Meniscus lesions are frequent injuries of the halfbacks and midfielders. They must frequently shift body weight from one leg to another, which causes a semirotation movement and pressure on the knee and exposes the knee ligaments to distension and torsion. Strikers are frequently involved in collisions

and falls inducing injury to soft tissue. They are particularly vulnerable to deliberate fouls and are often running at top speed when a fall results in multiple injuries (3).

Environmental aspects may increase the hazard of soccer play. Weather conditions may increase the difficulties of balance and coordination in executing tackles or dribbling and kicking the ball (78). Leng (36) reported an increased rate of cramps and muscle spasms in the Malaysian youth team players in colder than normal conditions. Extended warm-up and appropriate clothing would seem advisable under such circumstances. Risk in playing on artificial surfaces depends on the type of turf, how long it has been laid down, the amount of use, and drainage from the surface. Ideally, grip characteristics of artificial turf would be taken into account in the design of shoes for this type of surface.

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4. TRAINING

TRAINING ROUTINES

Training implies preparation for competition. The basic skills of the game are practiced repeatedly so that they can be more effectively employed in match play. Additionally, various drills are rehearsed so that individual players may be more easily integrated into tactical defensive and offensive units. These drills are perfected for implementation in match play plays. Besides the skill and tactical aspects, training sessions must also include practices providing the physical and physiological training stimuli to enable players to meet the demands of the game. Since positional roles have to some extent their own specific requirements (29, 40), some training routines should be tailored to individual needs. Since effective team play involves all members, group practices can be expected to dominate training procedures. This has the added value of facilitating the building of group morale.

Discrete objectives of soccer training have been summarized by Wade (47). These include the practice and improvement of individual and team skills; the training of endurance, power, and mobility; and the instilling of the correct mental approach to competition. It follows that a training program can be organized into components which emphasize particular training aspects. It is possible to classify soccer training routines on the basis of manifest objectives (27). Figure 4 indicates the temporal distribution between eight routines that commonly constitute a complete training session in the program of English League professional teams

(30). The categories include a "recovery" component comprised of the periods between work routines to allow recovery from the prior exercise or preparation for the impending one. The interlude affords an opportunity for the coach or trainer to give instructions to his players.

It is advisable to commence daily training with a period of light exercise (21, 28). This warm-up serves as physiological and psychological preparation for the harder exercise to follow. A moderate elevation in the temperature of muscles promotes more efficient performance, probably due to accelerations in enzyme actions associated with muscle contraction. The warm-up also represents an elementary preventative measure to avoid injury during training or competition. A higher incidence of muscle soreness has been reported when a sprint was not preceded by warm-up (11). The muscles most frequently injured during strenuous activity without preliminary warm-up are the antagonists to the strong contracting muscles (12).

In general, preparatory activity prior to athletic competition in a range of top sports participants occupies about 25 minutes (50). This activity comprises an easy warm-up jog which is practiced by most sportsmen. In the training of English League soccer players this takes on average about 8 minutes and is performed at a heart rate of about 120 beats/minute (30). Calisthenics describes mobilizing exercises implicating the major joint-complexes of the body. Apart from their value in the warm-up process, these exercises can involve specific joints that operate in competition at or close to the limit of their range of movement in a particular plane, producing an improvement in joint flexibility. Mobilizing exercises may be performed actively or passively to the limit of the range of movement at a particular joint or at the end of the range. Passive exercises could employ a partner to forcibly maintain a limb at its limit of mobility and so prevent the automatic stress-stretch recoil activated as a protective device by receptors in the tendons involved. Passive mobilizing methods improve flexibility either by proprioceptive facilitation or by reducing pain thresholds at the joint but require close supervision to avoid overtraining tendons or ligaments. Some authors have concluded that inadequate attention has been paid to flexibility by soccer players (e.g. 1, 27), only 7 minutes/day being devoted to calisthenics by English League professionals.

A further aspect of the warm-up process is its gentle introduction to the motor pattern of the competitive event. The skills routine affords this opportunity of executing the basic playing skills individually or in small groups before the more intensive routines with the ball. It is likely that insufficient attention is paid to this by most soccer teams prior to kickoff, though substantive evidence to support this is awaited. Investigations in the training of professional players indicate these practices are conducted at moderate levels of intensity eliciting mean heart rates of less than 130 beats/minute. With highly skilled players this intensity could be increased as the routine progresses to more closely correspond to the intensity of

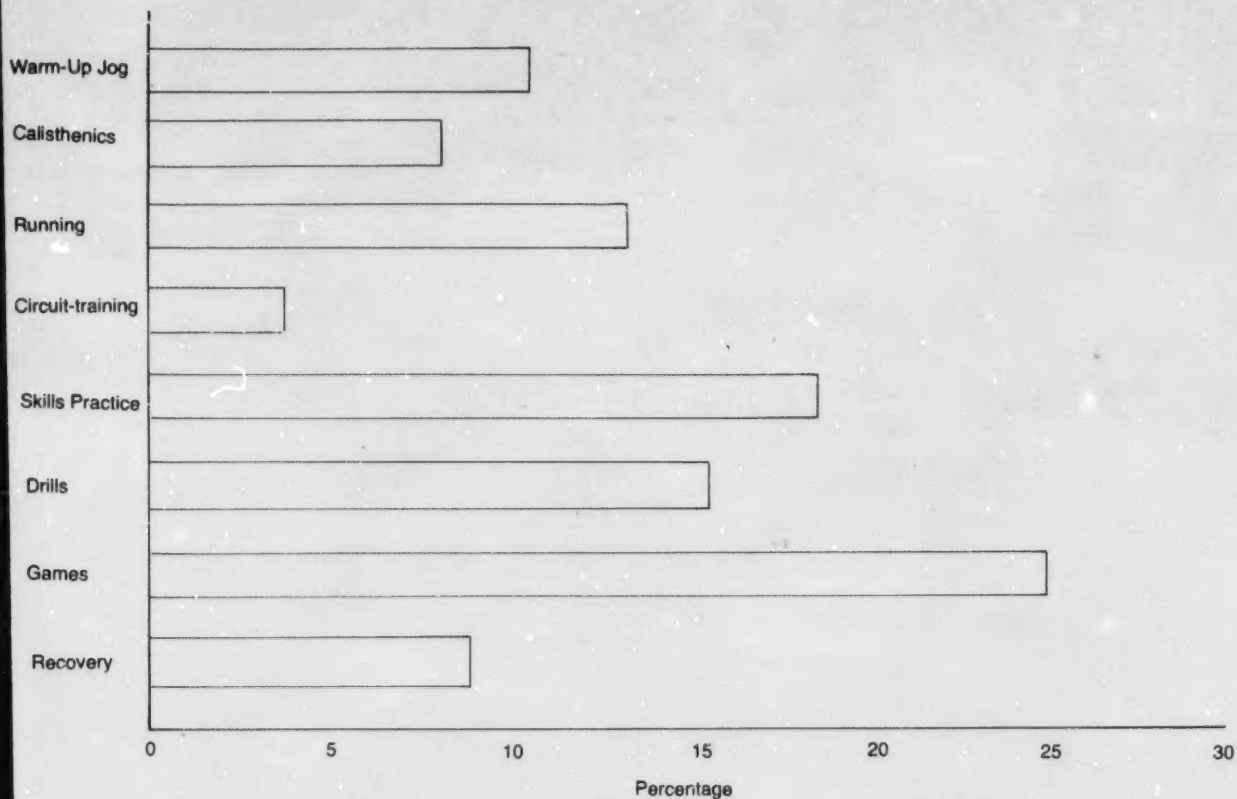


Figure 4. Proportion of overall training time allotted to each training routine.

match play where the skills must be put into operation. With learners skills practices should be conducted at moderate exercise intensities to avoid fatigue which inhibits skill acquisition (23).

Running and circuit-training routines have broadly similar aims in improving cardiorespiratory efficiency. This is of particular importance in the preseason training of players. Fardy (15) investigated the effect of a 10-week training program and 5 weeks detraining on selected cardiac and metabolic measures in the University of Illinois soccer team. The training program resulted in significant improvement of cardiorespiratory endurance, $\dot{V}O_2$ max increasing by 15.5%. The 5 weeks detraining period resulted in significant deterioration in fitness gains. Reilly and Thomas (31) concluded that their English League subjects had low endurance fitness levels at the end of a 9-week closed season. A 6-week period of physical conditioning produced significant training effects on the circulatory system in all players except the goalkeepers, who did not undergo the same rigorous training regimes as outfield players. These training effects were maintained but not further augmented during the competitive season.

Studies during the competitive season in other sports have shown that circulatory efficiency may remain stable in track athletes (2, 24, 38) and basketball players (10), may deteriorate as in international skiers (18), or may continue to improve as in canoeists (7), wrestlers (36), and swimmers (6). From these and other studies (e.g. 35, 39, 41) it seems that training effects during the competitive season differ between sports and probably between levels of participation, and that the preseason conditioning program affects variations in subsequent training states. In English soccer players the training effect in the circulatory system was secured at a cost of starting the competitive season at suboptimal levels of strength and power (31). This could be avoided by introducing strength and power training into the preseason conditioning regime and by encouraging some voluntary training during the off-season.

Running routines can be employed for training of the aerobic capacity to improve endurance or for training the anaerobic capacity to improve speed and speed-endurance. Intermittent work effectively organized with short recovery periods following maximum bursts can improve the tolerance to lactate production as well as improve the aerobic power (16). This would seem an important training requirement in view of the relatively high levels of blood lactate reported in soccer players at the end of a match (4). The main merit of intermittent training is its similarity to the movement activity of the game. The fidelity of the training routine can be further improved by introducing sharp halts and turns as in shuttle running or in interval maze runs over and around various obstacles, or in performing the running routines while dribbling a ball.

Circuit training, if properly arranged, can be effective not only in developing local muscle strength but also in boosting cardiorespiratory fitness (3). Training muscle strength implicates the principle of overload which implies that for an

effective strength training stimulus the muscles should operate against a resistance beyond that to which they are normally accustomed. An inherent limitation to squad circuit training is that work loads may have to be fixed to suit the capacity of the poorest member of the group. Delay between work periods may occur where the individual is permitted to alter the load at a work-station to suit his performance capability. Multistation equipment for squad training can facilitate the organization of strength and circuit training. This will be especially effective where the apparatus incorporates a variety of resistance modes, including isokinetic machinery, and allows for eccentric and concentric muscle action (32).

The value of drills training can be enhanced by performing this routine at high intensity at a level equal to or above competition stress. This may be achieved by some form of pressure training where the expressed purpose is to force the execution of game maneuvers under exacting conditions. An example might be the practice of defensive moves by confronting two center backs with three attackers or the use of conditioned games which limit possession of the ball to not more than two touches to improve passing skills. Ultimately the individual and team skills must be employed in full-scale 11-on-a-side competition, which explains why the greatest relative amount of training time is devoted to games (30). There has, however, been little research attention to the degree to which various soccer drills perfected in training transfer to competitive conditions.

HABITUAL ACTIVITIES

Soccer teams compete regularly on a weekly basis during the playing season. The frequency of match play may be increased in the case of successful teams involved in both league and cup competitions or in outstanding players featuring in representative matches. University players with affiliation to extramarsity clubs may participate twice weekly in match play. Generally, soccer fixtures are arranged to provide for weekend competition. This allows a 6-day period as a buildup for each game. The main difficulty in a match program involving three games in 8 days is that it leaves inadequate time for progressive training to take place.

The normal 8-day cycle adumbrated by Wade (47) has the 1st and the 8th days as match days. After recovery from competition on the first day, a progressive increase in training load was recommended for the following days to reach a peak in midweek, followed by a progressive reduction to a light training day 24 hours before the second match on the 8th day. Strenuous training sessions should be avoided the day before competitions to avoid depletion of glycogen stores in the

thigh and leg muscles (34). Figure 5 shows how the energy expended in training by English League players conforms to this weekly cycle (33). After a rest day following Saturday competition the mean energy expenditures in training show a

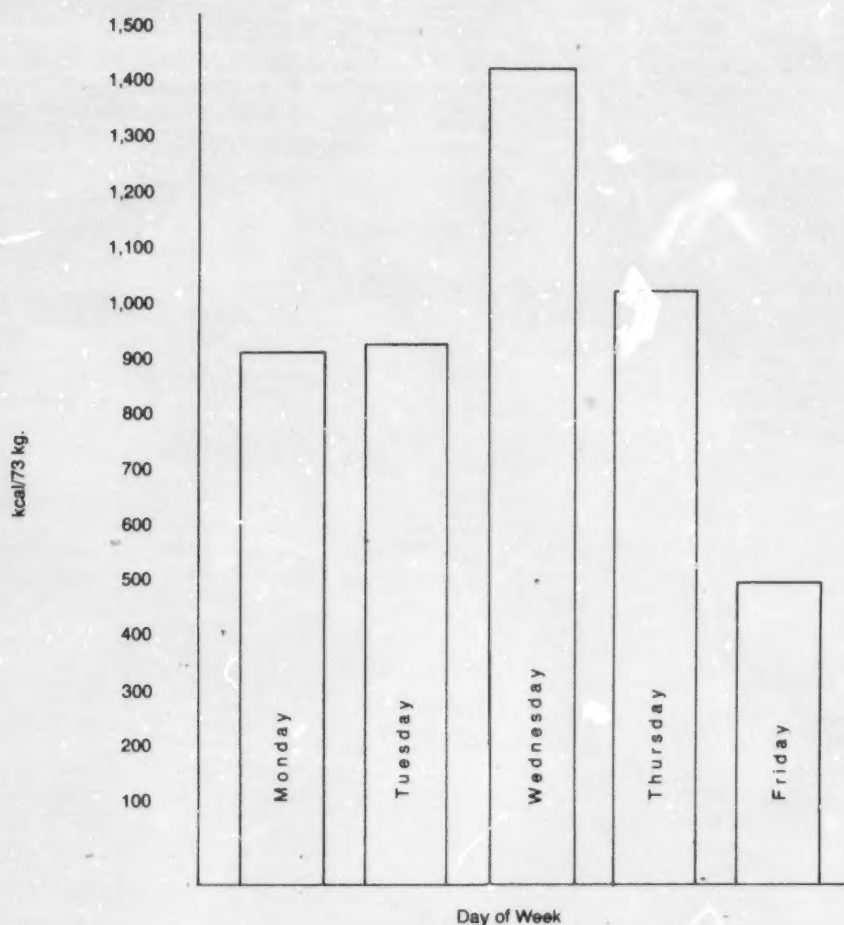


Figure 5. Distribution of daily energy expended in training according to the day of the week.

buildup from Monday to a Wednesday peak and a subsequent reduction to a trough on Friday in preparation for further competition on the Saturday. This cycle allows a spiral of load-fatigue-recovery to be administered in accordance with sound training principles (21).

English professional soccer players were reported to spend on average 75 minutes in daily training. Their mean daily energy expenditure was estimated to be about 3,506 kcal (33). This slightly exceeds normal values but lies below the 3,660 kcal reported for coal miners (14) or the 3,670 kcal for forestry workers (13) and well below the values computed by Grafe (17) for international sportsmen in full training in other sports. The energy expenditures fluctuated between days, exceeding 4,000 kcal in midweek when the duration and intensity of training was greatest. The retention of the daily energy output at an unexceptional level was attributed to the disproportionately large amount of time spent resting. The professional soccer player is entitled to be called *homo sedentarius* as well as *homo sportans* and could expend considerably more energy per day without undue physiological endangerment.

Other reports suggest greater energy output in footballers. Values up to 5,350 kcal/day have been estimated for East German players, though no data on the length or frequency of training sessions was presented (17). Junior High School and High School footballers in Japan spend 2-3 hours/day, 6 days each week in football practices. These footballers excelled in endurance fitness when compared with their classmates but were not so outstanding in terms of muscular strength and power (20). It is likely that such prolonged training sessions are unnecessary and particularly so when irreconcilable with other educational needs in the younger age groups.

SKILLS

The acquisition of complex motor skills is best achieved under conditions where fatigue is absent. Once these skills have been entrained, their employment in competition can be enhanced by training under stressful conditions. Execution of game skills in emergency can be practiced by some form of pressure training. One player may be subjected to a concentrated service of the ball and required to repeatedly produce certain skill patterns with a decreasing time for rest or recovery. The intended outcome is that the skill can be automatically and accurately produced when appropriate in match play.

Match analyses have to some extent clarified the emphasis to be placed on such fundamental game skills as shooting, heading, dribbling, tackling, throwing-in, and goalkeeping (40, 45, 46). About half of the skills used in games involve kicking, and a third involve keeping possession. The proportion increases for both kicking and keeping possession the greater the skill level of the team (46),

suggesting a positive relationship between possession and match result. Outfield players as a whole cover about 3,200 m dribbling the ball, much of it at high speed (28). Clear shots at goal occur at a frequency of about once every 5 minutes (40). The number of skills leading to a shot at goal is usually low, though the efficiency of shooting increases when there is a greater succession of skills. Since games are decided on the basis of goals scored and shooting opportunities are moderately rare, the implication for training is that shooting drills are important for effective preparation for competition, particularly in strikers to whom most scoring opportunities fall. This will involve practice of heading as well as kicking skills.

It is apparent that the speed with which the ball is accurately moved is important in shooting and in passing moves, though in certain conditions some speed may be traded for accuracy. The speed of ball movement has received some research attention, particularly with reference to the action of the kicking leg. Shibukawa (37) considered the body of a kicker at impact with the ball as a system of rigid bodies connecting at three points of hip, knee, and ankle. The ratio of ball and foot speeds was found to be highest when both knee and ankle joints were fixed, next highest when the knee joint was free and the ankle fixed, lower when the knee joint was fixed and the ankle free, and lowest when both joints were free. In all cases investigated the hip joint was free. Results showed that the ball speed was greatly influenced by fixing joints of the kicking leg as well as the foot speed at impact. The greater the foot speed just before impact, the faster the resultant ball speed. For a given foot speed before impact, skilled players produced higher ball velocities than unskilled, indicating that mechanical considerations do not entirely account for the difference between ability levels.

The positive relationship between the speed of the kicking foot and ball speed was confirmed in another study of instep kicking (44). The swing of the kicking foot was found to be accelerated until it contacted the ball and this was more prominent in well-trained players. Contact time between foot and ball was greater when the speed of the kicked ball was great. This seemed to be influenced by flexing and extending movements at the kicking ankle joint when giving impact to the ball.

The ball speed kicked by top Olympic soccer players was found to be 25.8-30.8 m/second compared with 21.2-23.1 m/second for varsity footballers (42). The loci of the body parts measured on the Olympic players showed longer moving distances than in the lower ability group, especially in follow-through after impact. At the moment of ball contact, the angles at the ankle and hip joints were greater in the higher proficiency group. All subjects stepped their pivot legs heel first, which extended the final step distance. This heel plant produces greater stability for performing the kick. At the moment of impact the angle of the knee of the pivot leg was minimal.

It seems that ball speed in kicking increases with experience in the game. Asami and Togari (5) reported a positive relationship between knee extension power and

ball speed from instep kicking, both increasing with experience in the game. These data support continued practices of various kicking forms in training.

Throw-ins seem to require a degree of specific skill as well as being dependent on fitness factors. The throw-in distance of soccer players has been found to be related to pull-over strength and trunk flexion strength (43). Training methods using a medicine ball were shown to increase physical fitness factors without a corresponding increase in throw distance. These results suggest that individual players should be preselected to take tactical long throws.

Goalkeepers are directly involved in play more frequently than any individual outfield player. The main goalkeeping skills include diving, catching, and punching the ball, as well as correct positioning to save shots from opponents or receive back passes from colleagues. Additionally, kicking and throwing the ball long distances accurately are important since the goalkeeper distributes the ball approximately 70 times per match (29). Since he may have little time in emergency situations for decision making, he should be subjected to pressure training involving repetitive shooting from various angles and ranges. Continued practice will enable him to anticipate ball flight earlier. This prediction is facilitated in skilled goalkeepers by their tendency to fix their eyes on the opposing player, while eye-fixation of unskilled players in this position tends to be on the ball (22). Instructions to keep the eyes on the ball seem to be ill-advised.

The question arises as to the extent to which soccer skills are amenable to test and measurement procedures. Heath and Rodgers (19) constructed a soccer test for fifth- and sixth-grade boys with reported reliability coefficients of between .71 and .74. The individual test elements consisted of a dribble, a throw-in, a place kick for goal, and kicking a rolling ball. Another test of general soccer ability consists of kicking a ball against a backboard as many times as possible in 30 seconds. The correlation coefficient between performance on this test and the subjects' ability as rated by their coaches was .85 (8). The reported reliability and validity coefficients for a wall-volley test at a target for a similar period was .92 and .83 respectively (8). These results suggest that soccer skill tests may be of use, particularly in the screening of junior players.

Other tests include fitness as well as skill requirements. A specific function test for young Czech footballers was designed which was simple and physiologically demanding and which reproduced the typical activity of match play (51). The test is carried out on a marked portion of the penalty area, one round measuring 123 m. The round consists of a sprint with a sharp change of direction, jumping over and crawling under obstacles, slalom dribbling of a ball between seven gates, and passing the ball for 25 m into a space 2 m wide once with each foot per round. The test is repeated after 45-60 seconds. Each individual is evaluated on time for the course, the accuracy of play, and the course of recovery pulse rates. The authors concluded that repeated tests of specific function gave a better indication of the

effects of training on young footballers than other nonspecific function tests. The test could be administered by coaching staff during training at selected points throughout the playing season.

STRATEGY

Some attempts have been made to apply conceptual models in the study of field invasive games (48, 49). These have included individual decision theory and game theory. Two major factors are considered in individual decision theory — whether there is enough information to warrant deciding on a particular move and whether the performer is sure of the priorities of the possible alternatives available. The factors can be presented in a two-sided pay-off matrix. The presence or absence of one or both (decisions with incomplete knowledge and decisions with unsure preferences) determine the amount of risk involved in finally opting for a particular course of action. In play, no one player can predict with certainty the outcome of a given kick or shot. Experienced players can, however, be expected to predict within a reasonable confine the approximate consequences of their actions while novice players are less able to decrease the apparent randomness in the outcome of a given action. Experimental results indicate that amateur and professional soccer players do not differ significantly in self-assessment of shooting skills, though significant mean errors occur in overestimation of their skills by schoolboy players (9). All players tend to overestimate their skill when the task seems hard and to underestimate it when it seems easy. The agreement between what players actually achieved in shooting and what they thought they could do was found to be more pronounced in Manchester and West Bromwich Albion professionals than in university or schoolboy players (9). This indicates that the margin of hazard more closely resembles the margin of safety in the experienced footballers.

In decision theory incomplete knowledge and unsure preferences interact to present two guises, depending on the decision being made. The first is based on an attacking strategy referred to as "maxi-min." Here the player attempts to obtain maximum gain with minimum opportunity of failure. This may mean that the gains decided on are conservative and have a low risk or a high likelihood attached to them. Mini-max is the second type of decision often apparent in defensive strategies. A minimum amount of damage is accepted while the widest possible defensive cover is provided as, for example, in a typical pass back to the goalkeeper. Soccer players and teams should be able to operate both strategies simultaneously or switch to either rapidly. There is however little empirical data on their applications in match play.

Though soccer involves inherent, game, and player probability, the preclusion of a systematic specification of each player's countless actions and judgments in

actual play means that extrapolations from game theory to soccer might not be valid. Cohen and Dearnaley outlined a series of obstacles to the application of game theory to soccer which did not extend to psychological probability (9). These authors proceeded to justify an experimental approach to studying the skill and judgment of footballers in attempting to score goals. In the circumstances of their experiment, involving an attacker being confronted by the goalkeeper alone, a precise relationship was established between the psychological probability of scoring a goal and the distance from the goal. Players expected to score once in a hundred attempts at an average distance of 31.8 m. Expectation of success increased with reduced distance up to 6.4 m from goal, which corresponds to a 99% success expectation. Any point nearer the goal was felt to diminish the chance of success as the goalkeeper would then be in a more advantageous position. There was a close correspondence between estimates and performance. Overall, the expected performance was slightly overestimated though the players succeeded in 5 out of 5 attempts at a mean distance of 7.9 m. The preferred method of scoring when the goalkeeper was allowed to advance was to shoot when the distance to the goalkeeper was still considerable. Half as frequently players attempted to pass the goalkeeper and shoot into an open goal, a maneuver displaying dribbling skills, while only rarely were hard shots along the ground a few meters from the goalkeeper attempted.

Since games are decided on the basis of goals scored, this aspect of play has inevitably generated much descriptive data. Most goals are scored from within the penalty area and many kicked goals are scored not by straight shots but side-foot efforts (9). Typically, successes come from positions at small angles, i.e. almost in front of the goal. Attempts outside the penalty area comprise about 40% of total attempts but these have a success rate of around 3% compared with a 30% success rate within the penalty area. In a study of a European Cup Final 7 out of 46 attempts were made from within the goal area and 6 of those 7 were scored (9). In actual play it seems that the chance of scoring a goal increases as the attempt is made nearer the goal, as might be expected. The number of attempts within the penalty area rather than the number of total attempts seems to be the distinguishing feature of winning teams. With rare exceptions it takes an average of 10 attempts to score one goal. The importance of getting the ball into the penalty area is supported by other studies. An investigation of the determinants of goal scoring indicated that the feature most common in goals was first-time shots close to goal, followed in importance by headers (49).

The number of skills displayed leading to shooting is usually low, mainly 0 and 1, though the efficiency of shooting is higher when skills are succeeded by 5-7 times (46). The number of passing moves prior to goal attempts or to loss of possession approximates a negative binomial distribution (25). This suggests that a long sequence of passes is not necessarily the best tactic. If the pitch is seen as divided into four transverse quarters, 50% of goals come from passing moves

originating in the quarter nearest goal. Of these, 50% come from regaining possession from the defense in that area (26). Consequently, exploiting defensive errors seems to be a prolific source of goals, as is astute utilization of set-pieces near goal which result in low pass-moves. Results support a direct method of attack to quickly reach the opponent's goal area. A long high kick into the opponent's penalty area presents a situation of high unpredictability for the defense and so weight its value as a gamble in favor of the attack.

The task of goal scoring falls heavily on strikers, though midfielders are often used to assume positions from which goal attempts might be made. Center backs are frequently employed in set-piece plays in attack with the expressed purpose of heading goals. An analysis of goals scored from different team positions in 3,192 English League matches over a decade indicated that the center forward accounted for 32%, the inside forwards a further 40%, and the two wingers 23% of the total scores (9). The outfield formation common in this period was two fullbacks, three halfbacks, two wingers, two inside forwards, and the center forward. The least productive position was fullback while the left-wingers scored significantly more goals than right-wingers. Whether this indicated asymmetry in offensive moves was not clear from the results. Further analyses might indicate optimal employment of striker characteristics in current team configurations.

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